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ABSTRACT

This folio of test items, contributed by a number of colleges and universities from their course, placement, entrance, or other institutional examinations, was compiled to aid teachers in constructing tests. Only those science courses offered in the first two years of college are represented by the scope of the items. The test items may also serve as models for those who are relatively inexperienced in item writing. A major consideration in using these items is that of relating them to the testing of various objectives. These questions and problems are arranged under some thirty subject matter headings in each of the two major subdivisions: Biological Science and Physical Science. The items are classified according to Bloom's taxonomy under the following major headings: Knowledge; Comprehension; Application; Analysis; Synthesis; and Evaluation. (AG)

ED0 54231

Questions and Problems

IN

SCIENCE

TEST ITEM FOLIO NO. 1

PREPARED BY

PAUL L. DRESSEL · CLARENCE H. NELSON

MICHIGAN STATE UNIVERSITY

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Preface to Folios of Test Items

THE PUBLICATION of this Folio of Test Questions constitutes an important new departure in the measurement of achievement in college courses. For some time standardized objective examinations of good quality have been available for measuring student accomplishment in broad subject matter areas. However, these tests, which are designed to be generally applicable, do not always include exactly the same topics that might be included in a given course in a particular institution, nor do they necessarily give the same emphasis to the various course objectives that a particular instructor might wish to give. To obtain a test that fits his own course precisely, the instructor often finds it necessary to build one himself; certainly, relatively few institutions can afford to maintain a special professional staff for this purpose. Unfortunately, most instructors are unable to devote the large amount of time and study necessary for the preparation of really good examinations, and consequently many "homemade" tests tend to be of poor technical quality. By making available a large pool of items of superior quality from among which the instructor can select any combination he desires, the new Folio of Test Questions makes it possible to retain certain advantages inherent in the use of expertly constructed standardized tests while still giving the instructor the same measure of freedom he would exercise in building an examination of the homemade variety.

In addition to its value in improving the quality of locally prepared tests, the Folio of Test Questions will also serve to release for more effective use the time that the instructor now expends on the difficult task of constructing test questions—and expends unprofitably, in many instances. It will no doubt also serve as a source of ideas for use in stimulating class discussion and in developing special assignments or projects, as well as serving as a source of leads and models for constructing additional test items.

The idea of making available to university instructors a folio of test questions of this nature first began to achieve some semblance of feasibility about five years ago, when it was discussed at the Conference of University Testing Officers that was held at Educational Testing Service in Princeton in October, 1950. It was the offer of testing materials by this group that made it possible to proceed with the idea of the folio, and their active encouragement helped materially throughout.

A great many institutions have contributed to this project. Among those which have made particularly outstanding contributions of items have been Michigan State University, University of Chicago, Chicago City Junior College, Dartmouth College, Antioch College, University of Florida.

The work of collecting and classifying the items in this folio and in preparing the volume itself for publication has been performed by Paul L. Dressel of Michigan State University with the assistance of Clarence H. Nelson. They have brought good judgment and technical skill to their task, and to them is due the principal credit for the nature and quality of the publication. The system used in classifying items has been the one developed by a committee of college and university examiners under the leadership of Benjamin Bloom of the University of Chicago. (This system has recently been published in experimental form by Longmans, Green and Company, New York, under the title *Taxonomy of Educational Objectives.)*

The appearance of this folio of test questions in the natural science area (which is only the first in a series that will eventually, we hope, include similar folios of test questions in social science and in the humanities) opens up a new and very significant area of service in the testing field. The critical importance of good examinations is becoming more and more widely appreciated. It has long been recognized, of course, that soundly prepared tests are essential to fairness in grading and evaluation. More recently it has come to be realized that examinations exert a powerful influence on the character of both teaching and learning. Hence their nature and quality assume major importance in any effort to improve educational standards. I believe that the publication of the present volume marks an important forward step in education and in testing.

HENRY CHAUNCEY, *President*
EDUCATIONAL TESTING SERVICE

SECTION I

The Nature and Uses of the Folio

THE TEST MATERIALS included in this folio were contributed from a number of cooperating colleges and universities. With few exceptions, the questions and problems contributed had had prior use in course, placement, entrance, or other institutional examinations. In every case, items appear in the folio almost exactly as they were contributed—with no major editing undertaken to smooth out rough spots or to remove minor flaws and discrepancies in item construction. A thorough technical editing of all test items in a volume of this size would have increased its cost beyond the reach of many potential users and enhance its general utility only slightly. It is recommended, therefore, that the user who assembles tests from items in this folio should examine each selected item carefully and edit its wording to suit his own needs exactly. The collection here presented is a reasonably careful and organized selection from a much larger pool. Quite naturally, both the selection and organization were influenced by intended uses. These considerations will be discussed in some detail later in the introduction. Since the selection of questions is heavily dependent on the sources from which they were received, it is important that the procedure under which the original set of problems was collected be understood.

In soliciting contributions, the first consideration was that those individuals and institutions contacted be ones known to be actively concerned with the development of good test materials. Most of the materials collected were from colleges having an evaluation office. Institutions lacking such a central evaluation or testing service may not lack concern about the quality of their testing, but the existence of such a service is an overt indicator of that concern. Moreover, it is much easier to enlist cooperation from evaluators and examining units than from individual instructors in the contribution of test materials. A second consideration was that it was necessary to limit the range of courses from which problems were collected. There is a degree of commonality among science courses offered in the first two years and there are many more students and teachers involved in courses at this level. Furthermore, the problems of testing these larger freshman and sophomore groups are more pressing than are the testing problems in a more advanced course. Contributions, therefore, were requested only for science courses offered in the first two years. The request also indicated specifically a concern with science courses which were regarded as making a definite contribution to the general education of the students enrolled. For certain institutions, such as Michigan State College and the University of Chicago, all of the materials contributed came from general education science courses. One who studies carefully the items included in this folio will perceive that a large majority of the problems have originated in courses of general education flavor. This is the natural result of the fact that the introduction of general education courses often has evoked a concern about problems of evaluation. If the items of this folio were identified with the contributing institution, it would be evident that a very large percentage of the items are from a very limited number of institutions. This, likewise, is a natural result of the extensive testing programs and the centralized examination services existing in these institutions. The limitation in number of institutions and courses represented is not a serious one for the purposes of the folio, although the user should be aware of it. Since the primary purpose of this folio is to present the materials which will be useful to teachers in the area of general education science courses, the limitations in the courses and colleges represented may be an advantage rather than otherwise.

For some years there has been an exchange of materials among many of the institutions contributing items to this folio. One result is that some items or ideas originally developed in one institution later appear in tests used at others, so that it is not always possible to determine where a particular item was originally written. In sorting and classifying items for this folio a considerable amount of such duplication or repetition was found. In some cases the same basic idea was approached in rather different ways, a degree of similarity readily explained by the commonality in the content of the general education type courses from which the materials were collected. In other cases the similarity was of such order of magnitude as to indicate a common source. Occasional identical items were received from different institutions, indicating that advantage had been taken of the permission to use exchanged materials. Because of the predominance of materials from certain institutions and because of the difficulty in identifying the originator of a particular test item, no attempt has been made to credit the individual items included in this folio to the contributing institutions.

The remainder of this introduction is devoted to presenting the organization of the folio and to explaining the uses of it. This apparent reversal in the order of their significance results from the fact that efficiency in the use of the folio depends very much on a full grasp of its organization.

Organization of the Folio

Considerations Involved

Many possible modes of organization of test items readily come to mind. One might group together all items dealing with chemistry, for example, and this would be convenient for those teaching chemistry. Even among beginning courses, however, there is some variation in the number and nature of the topics included. This naturally leads to consideration of the possibility of using more specific content headings indicative of various topics covered in such courses. Such headings as these are equally useful for both the integrated general education type courses and the more traditional courses offered in particular departments. In general education courses much attention has been given to objectives and this would suggest that classification on this basis be made the primary consideration. It was our feeling, confirmed by the reactions of a number of teachers whom we consulted, that the selection and use of test items in science classes required as a first consideration that the questions be relevant to the content materials covered in the course. This does not necessarily mean that objectives are a secondary consideration, but results from the inescapable fact that one cannot test for a complex behavioral objective by using science facts and principles which the student has not studied. Of necessity, then, the subject matter covered by the item is the first consideration in determining its applicability in a particular course.

The grouping of test items according to the form of the item has some slight utility for those who either like to use but one form or wish to avoid certain forms because of a concern that the mechanical aspects of response to these forms will interfere with performance. Such an organizational scheme would mean that all items involving a true-false response would be placed together, all items of the five-response one-right-answer type would be grouped together, and so on. A moment's reflection on such an organization indicates that this structure has minor significance at best, since the type of item used in testing a particular concept, principle, or ability should develop out of the nature of the behavior which it is desired to elicit. It follows from this that it is not advisable to limit a single test to one type of item for the sake of uniformity. However, there may be real value in grouping together items which require somewhat the same mechanics on the part of the student in responding to them, because items requiring complex behavior often have complex directions so that a randomly ordered group of such items may be bewildering to the student. Other than this the grouping of items by form or type has no functional value.

One obvious and major distinction with regard to item type is found between objective test materials and essay materials. This folio is composed predominantly of objective test items, although some essay materials have been included. The paucity of essay questions results partly from the small number included in the examinations contributed. This in turn results from the nature of the sources and courses included which lean heavily on objective questions. Although essay questions are extensively, and often exclusively, used in many courses and by many instructors, they are not available for contribution to a collection such as this. Frequently essay questions are so specifically related in their phrasing to a particular course and so unimaginative as to be inappropriate for inclusion in a compilation for general reference. Where essay questions have been presented in this folio they are sufficiently distinctive to be easily differentiable from objective test materials, even though the same content and objectives may be involved. It did not seem desirable to place essay questions by themselves any more than it seemed desirable to group together objective items of similar form.

Still another possible consideration in grouping test items is to be found in an ordering on the basis of evidence concerning the difficulty and excellence of the item. Several of the contributing agencies or individuals consistently compute statistics on individual items which give some indication of the difficulty of the item and also of its discrimination relative to part or total test score. Such data are always affected by the characteristics of the particular group on which they are computed, and differences among college populations are such that it would not ordinarily be possible to judge the difficulty of a particular item for one group from the statistics computed on another. This impasse, and the lack of any statistical data for many of the items included in the folio, made it impossible to organize the items in terms of difficulty and excellence or to provide evidence on these characteristics.

This discussion does not exhaust the factors relevant to the organization of a folio of test items, but it does provide some background for understanding the following section which presents the organizing principles which were finally adopted.

The Organizing Principles

Science topics and subtopics must be the first basis for grouping items if they are to be most readily available to individuals for use in the classroom situation. In deciding upon the topics to be used it was agreed that they must be determined in part by items contributed, although an *a priori* list based on topics frequently included in beginning courses was developed. The topics used do not cover all those which might be included in first science courses or all those which might be covered in general education science.

The division between physical science and biological science provided the obvious first major breakdown and under these divisions have been inserted numerous headings and sub-headings. These categories are given in the table of contents with the page number on which the particular group of items begins, thus facilitating the locating of test items dealing with a particular topic. While care has been exercised in classifying items under these topics, there are some questions for which categorization is debatable. In fact, there exists a group of items of a miscellaneous sort which were not classifiable. Some of the debatable item classifications result from the deliberate attempt on the part of the question writer to produce a question which would cut across several different topics in science and thereby require a demonstration of a broad understanding or application of knowledge from several different science areas. Because of this the person who is seeking examples of test questions dealing with particular topics in science will do well to check a number of closely related topics, even though the one that he has in mind is explicitly given in the table of contents.

The importance of objectives in general education courses has been noted already. It is now quite common for those who approach the problem of testing on a systematic basis to use a double classification system involving both a specification of the content and the objectives to be covered. Blueprints or specifications of this type are necessarily the first step in developing a balanced examination. Such a blueprint illustrates the fact that when a series of questions is developed on a particular topic or unit of a course, a different objective may be involved in each item. One of the possible and desirable qualities of a set of items based on a particular problem or reading passage is that it brings together in a realistic way a number of different types of behavior. In such cases any attempt to break up an item in order to classify the various parts under the individual objectives would require much repetition and, even then, would lose the essential quality of the question.

A major problem with regard to the matter of objectives has been the lack of any generally accepted simple statement of objectives. There is a tendency for a group of teachers who become concerned with objectives to develop a lengthy list of many specific objectives. In stating objectives numerous semantic difficulties are encountered, and it is often found that the same idea will be stated in quite different words by different people. Typically, a statement of objectives adopted by one group of instructors will not be entirely acceptable or even understandable to another. Even when a verbal statement of an objective is accepted by several individuals or by different groups of individuals, there is always some doubt as to whether the different individuals have exactly the same kind of behavior in mind. This issue is somewhat less serious in the development of this folio because any particular objective is for practical purposes defined by the items which have been attached to that objective. A more serious problem is that of finding a statement of objectives which holds promise of being generally useful to all teachers of science. We were fortunate in that a group of evaluators and examiners, working over a period of time under the leadership of Dr. Benjamin Bloom of the University of Chicago, had developed a taxonomy of educational objectives in the cognitive domain, based upon the empirical approach of collecting and classifying items from many different institutions and many different areas of knowledge. This taxonomy, with the accompanying statement of rationale and exemplification in terms of test items, has just been published in experimental form.* Although it is too early to say how generally acceptable this taxonomy will be to teachers or even to the examiners and evaluators who have worked with it, the meaning of the various statements of objectives has become reasonably clear. The Taxonomy does have a degree of generality to it which should make it useful to teachers in all fields. Certainly the advantages of a commonly acceptable taxonomy of objectives are obvious in expediting exchange of test materials and in the discussion of the aims of particular courses. The complete Taxonomy is reproduced in Part 1 of the Appendices, although only the major headings and the first level sub-headings have actually been used in classifying items in this folio. The classification of items into the larger headings is sometimes a difficult task, especially when one recognizes that the task posed by an item may be different for one student than for another, or that it may be quite different for an entire class which has approached the topic from a point of view other than that assumed in the item. The behavior involved in dealing with a problem may often be as much a characteristic of the individual and the background of the individual who deals with the problem as it is of the problem itself. While in our particular culture it appears more expeditious to approach certain problems in a particular way, one cannot devaluate another approach which leads to a perfectly satisfactory answer. The simplest illustration of the complexity of item classification by objectives is that the most complex problem type of question may be, for certain individuals who have happened to face that issue before, entirely a matter of simple recall. Likewise, an item which is thought by a teacher to be a matter of simple recall may be, for some students who have forgotten the particular point, a problem worked out on the spur of the moment. The classification of any item under a particular objective is a fallible judgment, but nonetheless one upon which a fair degree of agreement has been achievable by individuals who have independently undertaken to classify the same group of items. In some cases two or more items dealing with the same idea have been included to illustrate somewhat different approaches to the same topic or even to the same objective. Finally, it has been necessary to group into a miscellaneous category certain items which were not amenable to classification under the scheme chosen. Since few, if any, of the items included here were originally written with the categories of the taxonomy in mind, we have generally chosen to interpret broadly the most relevant category rather than to have a large miscellaneous category. All of these classification problems and organizing principles will become clearer in the following section as we study more carefully a number of examples either chosen from, or similar to, those included in the folio.

Examples

The items which follow have been selected as representative of the various objectives of the Taxonomy reproduced in Part A of Section III, page 799. Some of the items contain technical flaws or deficiencies which we have chosen to retain and comment upon in lieu of any extended discussion of the finer points of item construction. An effort has been made to eliminate such flaws in the items found in the main reservoir although the critical user will undoubtedly detect some that we have overlooked. The items are coded only into the major sub-headings, although some of them could be assigned to the finer subdivisions of the Taxonomy.

1.00 Knowledge

1.10 Knowledge of Specifics

1. Ecology is the science of the

   A. economic value of organisms.
   B. development of organisms.
   C. heredity of organisms.
   D. nutritive value of organisms.
   E. relationship of organisms to their environment.

2. An element which accounts for little, if any, of the weight of a living organism is

   A. oxygen. B. carbon. C. helium.
   D. nitrogen. E. hydrogen.

3. A hormone can best be defined as

   A. any product of an endocrine gland.
   B. that which distinguishes an adult male from an adult female.
   C. a substance which neutralizes toxin in the blood.
   D. an enzyme which is found in blood plasma.
   E. a specific substance secreted by one organ with effects on other organs which it reaches via the blood.

DISCUSSION: These three items require respectively the knowledge of terminology, of a fact, and of a definition. The correct answer to item 1, E, may not be in the exact words used in a particular textbook but does not deviate far from it. The answer to item 2, C, may not be taught, but is readily obtained by elimination since the other four elements are inevitably indicated as essential components of organic material. The answer to item 3, E, may well be given away by its length relative to the distractors. Note this weakness in 1 also. This results from the natural tendency of item writers to properly qualify and delimit the intended right answer, while forgetting to provide at least one alternative of equal or greater length. Some care has to be taken in lengthening wrong alternatives, for added detail may make their unsuitability apparent. Students are frequently influenced in their choices by length or unusual phrasing.

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*_Taxonomy of educational objectives._ A Committee of College and University Examiners, Benjamin S. Bloom, Editor. New York: Longmans, Green and Co., 1954.

1.20 Knowledge of Ways and Means of Dealing with Specifics

4. In order to arrive at the solution to a problem a scientist usually formulates and tests

A. facts. **B.** theories. **C.** principles.
D. laws. **E.** hypotheses.

5. Which of the following means most nearly the same as the word "control" as used in describing a scientific experiment?

A. Preliminary trial experiment.
B. Experiment with the variable factor.
C. Repeat experiment. **D.** Comparison experiment.
E. None of the above.

6. Which of the following classification categories includes the remaining four?

A. Order. **B.** Species. **C.** Class.
D. Family. **E.** Genus.

7. The scientific name of the white oak is *Quercus alba.* These two words designate the

A. phylum and class. **B.** phylum and family.
C. family and species. **D.** class and family.
E. genus and species.

Discussion: The items under this sub-heading continue to involve facts and terminology but test the facts and terminology in reference to their significance in organizing, studying, judging, and criticizing knowledge. Thus, item 4 is less concerned with the definition of hypotheses than with determining whether the student recognizes the role of hypotheses in scientific research. For such an item an automatic response may result from the junction of the verbs "formulate" and "tests" with hypotheses, since these verbs are infrequently coupled with the other choices.

Item 5 is clearly testing knowledge of terminology, but of terminology used in the experimental situation. The answer, comparison experiment (D), is not a definition of control, but is "most nearly the same" in meaning. The E response (none of the above) is often useful, particularly in problems with a simple numerical answer. Here this alternative is somewhat dangerous since the fact that none of the preceding answers is entirely correct places some strain on the phrase "nearly the same as."

Item 6 (answer C) and item 7 (answer E) require knowledge of classification categories. However, there is a slight difference to be noted in the behavior required. Since there are numerous other categories than the five given, choice of the correct response for item 6 requires an examination of all five of the alternatives presented. For item 7, the student who knows the right answer should select it at once with only passing reference to the distractors.

8. The usual path traversed by a drop of blood in passing from the region of the knee to the heart, thence to the lung in human circulation is

H - L
2 - 2 **A.** capillary, small vein, iliac vein, vena cava, left ventricle, left auricle, pulmonary artery, capillary in lung.
1 - 6 **B.** capillary, small vein, vena cava, iliac vein, left auricle, left ventricle, pulmonary artery, capillary in lung.
2 - 14 **C.** capillary, small vein, iliac vein, vena cava, left auricle.
36 - 15 **D.** capillary, small vein, iliac vein, vena cava, right auricle, right ventricle, pulmonary artery, capillary in lung.
6 - 5 **E.** capillary, small vein, iliac vein, vena cava, right auricle, right ventricle, pulmonary vein, capillary in lung.
3 - 8 omits

9. Blood clotting occurs as a consequence of the following steps:
1. hemmorrhage → release of thromboplastin (thrombokinase)
2. calcium + thromboplastin + prothrombin → thrombin.
3. thrombin + fibrinogen → fibrin.

The blood platelets play a role in

A. step 1. **B.** step 2. **C.** step 3.
D. steps 2 and 3. **E.** none of the above steps.

Discussion: Item 8 requires knowledge of the path traversed by the blood circulating through the human body. The first two phases of the path are identical so that the distractors are not easily eliminated without some study. At the third stage of the path, distractor B is out; at the fifth stage, distractors A and C are seen as incorrect; and only at the seventh stage is the right answer, D, distinguishable from E.

For this item, data on the performance of two groups of 50 students are given. These groups are composed respectively of the high scoring 27 per cent and low scoring 27 per cent of 185 students selected at random from a larger group of several thousand who took the test which included this item. The numbers recorded under H and L preceding each choice indicate the actual number of students in the high and low group which selected that response. Alternatives B and C discriminate between the good and poor students, but A and E attract approximately an equal number of both groups. Forty-nine per cent of the students involved in this analysis failed to get the item right, indicating an item of average difficulty for this particular group. Since 72 per cent of the high group against 30 per cent of the low group gave the correct answer, the discrimination of the item would be regarded as satisfactory. Such data are extremely helpful both in checking on student performance on particular topics and in revising items.

Item 9 requires familiarity with the sequence of steps in blood clotting, but reproduces the steps in order to reduce the role of memory on the primary task and also to provide a structure which simplifies the wording of the item alternatives. This item deals in a simple way with an item of knowledge covered in the course but emphasizes understanding one phase of a process rather than recall of the sequence. The correct answer is A (step 1). If a response of the type "none of the above steps" is extensively used, an occasional item should be introduced in which this alternative is the correct answer. Otherwise students soon learn to disregard this choice.

1.30 Knowledge of the Universals and Abstractions in a Field

Items 10 - 13 are statements about evolution. They are to be judged with reference to the following theories:

THEORIES

- **A.** Hereditary changes are brought about by the use or disuse of organs or parts of the body.
- **B.** Among the superabundance of organisms produced each generation there is competition for food and mates, and against enemy predators. The survivors tend to transmit to their offspring those traits which enabled them to survive.
- **C.** Sometimes genes may undergo changes and produce new characters in a plant or animal which will breed true through successive generations.

For items 10 - 13 mark each statement according to the following key:

KEY

1. The statement is true and supports Theory A.
2. The statement is true and supports Theory B.
3. The statement is true and supports Theory C.
4. The statement is true but does not support any of these theories.
5. The statement is probably false.

10. Hornless cattle which breed true for hornlessness have ultimately resulted from dehorning, generation after generation, for several hundred years.

11. The giraffe got its long neck by repeatedly stretching for leaves in tall trees; each increment of length thus attained was passed on to the next generation.

12. The short-legged dachshund and the long-legged greyhound have been developed by the perpetuation of abrupt drastic variations.

13. In an environment undisturbed by man, a little more fleetness, a bit more strength, a slightly greater protective coloration, a more responsive nervous system, or any of thousands of differences may be the decisive factor which means life or death to the creature in danger.

Discussion: Items 10-13 are based on the theories of Lamarck, Darwin, and DeVries, each summarized into a single sentence. The student demonstrates an understanding of these theories by distinguishing between the truth or falsity of a statement and then indicating its relation to the three theories. The statements (10 and 11) are false but, if thought to be true by a student, would be regarded as supporting Theory A. Statement 12 is true, and tends to support Theory C. Statement 13 is practically a restatement of Theory B, hence is regarded as true and supporting that theory. These items may be regarded as requiring the student to relate specific evidence to the theory or theories it tends to support. Further complications can be introduced by introducing evidence which supports more than one of the theories.

2.00 Comprehension

2.10 Translation

14. Which one of the following is the best description of what is meant by basal metabolic rate (B.M.R.)?

- **A.** The daily calorie output of a person exercising lightly and subsisting on the minimum diet to remain alive.
- **B.** The oxidation rate in an active individual going about his daily routine and maintaining normal weight.
- **C.** The respiratory coefficient in base industry organisms (algae and protozoa).
- **D.** The oxidation rate which will just maintain the life processes of a person in a state of rest.
- **E.** The amount of heat required to raise the temperature of one kilogram of water one degree centigrade.

2.20 Interpretation

15. Mendel's chief aim in his experiments in plant-hybridization is to

- **A.** discover the laws generally applicable to the formulation of hybrids and their offspring.
- **B.** demonstrate the universal application of the phenomena of dominance.
- **C.** invalidate Darwin's theory of evolution by explaining Darwin's "new variations."
- **D.** uphold the doctrine of the strict separation of the inheritable (germinal) from the non-inheritable (somatic) protoplasm.
- **E.** discover how seven characters are inherited in peas.

2.30 Extrapolation

16. If the evolutionary trend of the past half million years continues for the next half million years, human beings are likely eventually to

- **A.** have a smaller cerebrum than at present.
- **B.** be completely bald in both sexes throughout life.
- **C.** run on all fours instead of walk erect.
- **D.** be completely covered with a heavy pelt of hair.
- **E.** have long tails.

Discussion: Although item 14 might be regarded as involving knowledge of terminology and so classified, the basal metabolic rate has been here regarded as a complex abbreviation requiring translation. For this reason, it is classified as a comprehension item. Whether the actual behavior of the student in answering the item justifies this classification depends largely on whether the correct answer (D) is a memorized definition or a rephrasing requiring some depth of understanding.

Item 15 is regarded as involving a summarization and interpretation of Mendel's work on plant-hybridization. If taught in essentially the form given, A being the correct answer, the item would be a knowledge-type item. Here it is assumed that the student has not had this idea presented in these words and quite possibly nothing has been said at all about Mendel's chief aim.

Item 16 requires an extrapolation into, or a prediction of, the future from knowledge of past trends. Four of the possible responses contradict known trends, whereas B is a natural extension of the gradual decrease in man's covering of hair. Although not a significant defect, the fact that the amount of hair is the only characteristic to be given double attention (B and D), may suggest to an alert individual that the answer lies between the two.

3.00 Application

17. A patient who has had a hemorrhage is given, by accident, a liberal injection of distilled water into one of his veins. This would

A. have no unfavorable effect as long as the water is free of germs.
B. be fatal, because there would be too much fluid.
C. probably be fatal, because the red blood cells would rupture.
D. probably be fatal, because the red blood cells would shrivel.
E. have no serious effect because "thinning" of the blood is a natural phenomenon.

Discussion: Item 17 is regarded as presenting to students a problem which is new but which can be answered by application of the principle of diffusion. The student should recognize C as the correct answer by reasoning that distilled water will diffuse through the walls of the red blood cells and rupture them because of the differential in concentration of solutes. It is assumed that this particular illustration has not been presented in the discussion of diffusion.

4.00 Analysis

4.10 Analysis of Elements

Items 18 - 22 are based upon the following selection. It was written in 1688 by Redi, an Italian physician who was known for his attainments in literature and natural science. Read the selection carefully before answering the items.

"Having considered some observations of flies on meat, I began to believe that all worms found in meat were derived directly from the droppings of flies, and not from the putrefaction of the meat, and I was still more confirmed in this belief by having observed that, before the meat grew wormy, flies hovered over it, of the same kind as those that later lived in it. Belief would be vain without the confirmation of experiment; hence in the middle of July, I put a snake, some fish, some eels of the Arno, and a slice of milk-fed veal in four large, wide-mouthed flasks; having well-closed and sealed them, I filled the same number of flasks in the same way, only leaving these open. It was not long before the meat and the fish, in these second vessels, became wormy and flies were seen entering and leaving at will; but in the closed flasks I did not see a worm, though many days had passed since the dead flesh had been put in them. Outside on the paper cover there was now and then a deposit, or a maggot that eagerly sought some crevice by which to enter and obtain nourishment. Meanwhile the different things placed in all flasks became putrid and stinking; the fish, their bones excepted, had all been dissolved into a thick, turbid fluid, which on settling became clear, with a drop or so of liquid grease floating on the surface; but the snake kept its form intact, with the same color, as if it had been put in but yesterday; the eels, on the contrary, produced little liquid, though they had become very much swollen, and losing all shape, looked like a viscous mass of glue; the veal, after many weeks, became hard and dry."

Directions: For items 18 - 22 mark space

1. if the statement is an observation.
2. if the statement is a basic assumption of a scientist.
3. if the statement is an hypothesis.
4. if the statement is a conclusion based on evidence.
5. if the statement does not belong in any of the above categories.

18. "I began to believe that all worms found in meat were derived directly from the droppings of flies."

19. "Belief would be vain without the confirmation of experiment."

20. "It was not long before the meat and the fish, in these second vessels, became wormy, and flies were seen entering and leaving."

21. Maggots do not develop in meat which is protected from flies.

22. The nature of the fluid resulting from the putrefaction of the fish was not investigated.

Discussion: Items 18-22 require distinguishing among observations, assumptions, hypotheses, conclusions, and other statements not so classifiable. The assumptions involved here are at a level descriptive of the scientific method or attitude although they may be phrased in reference to the particular experiment. Item 18, although not stated explicitly as an hypothesis, is clearly just this. Any doubt as to Redi's attitude on this is removed by the following sentence, item 19, which makes explicit the scientist's view that the implications of the hypothesis just stated must be investigated. Item 20 is simply an observation. The categorization of item 21 is somewhat debatable. The temporal sequence of the items implies that this statement is one summarizing the results of the experiment and that it should be regarded as a conclusion, albeit a tentative one. Disregarding the temporal sequence or discounting the strength of this single experiment, the statement might readily be regarded as a rephrasing of item 18 and, like it, be regarded as an hypothesis. "Conclusion based on evidence" was regarded as the best answer.

Item 22 is a statement for which the factuality is not determinable by the evidence given; it is not, therefore, a conclusion to be drawn from the data at hand. With additional information about Redi, it might be that truth or falsity would be determinable, but even so this is irrelevant to the categories provided. Contention that the statement is an "observation" by a commentator on Redi's work involves a shift in the meaning of the word "observation." With some reason it might be argued that a science historian might make this statement an hypothesis to be carefully investigated through careful review of all of Redi's work. This introduces considerations far beyond those specified. The best answer is definitely the indication that the statement "does not belong in any of the above categories."

4.20 Analyses of Relationships

Hypothesis: Carbon dioxide (CO_2) is a more potent factor in the control of breathing than oxygen (O_2).

Experiment: If air from a small closed chamber is breathed and rebreathed, and care is taken to remove all the expired CO_2, the O_2 of the chamber will gradually be used up. The concentration of O_2 in the blood gradually diminishes, with no appreciable change in the blood CO_2 concentration. In such an experiment, breathing is accelerated relatively little, even though the experiment is carried to the point where the O_2 content of the blood is considerably reduced.

However, if the same experiment is repeated except that the expired CO_2 is not removed from the system but is allowed to accumulate to be rebreathed again and again, a very marked acceleration of respiration, as well as extreme discomfort ("air hunger"), will result. In this experiment O_2 is being depleted from the blood as before, but CO_2 is accumulating.

Finally, if an individual breathes air containing the normal, or even more than the normal, percentage of O_2, but containing only a slight excess of CO_2, respiration will again be accelerated.

Here the O_2 concentration of the blood has been maintained practically unchanged, and the CO_2 content has increased.

—Adapted from Anton J. Carlson and Victor Johnson's *The Machinery of the Body.*

After the item number on the answer sheet which corresponds to that of each statement blacken space

- **A** if the statement supports the hypothesis, and this support is justified by the experimental data given.
- **B** if the statement supports the hypothesis, but this support is *not* justified by the experimental data given.
- **C** if the statement contradicts the hypothesis, and this contradiction is justified by the experimental data given.
- **D** if the statement contradicts the hypothesis, but this contradiction is not justified by the experimental data given.
- **E** if the statement is not relevant to the hypothesis.

Following these instructions were eleven statements, each of which probed into some aspect of the experimental procedure and required the student to carefully analyze the relationship of the statements to the stated hypothesis. Then the problem continues as follows:

After the item number on the answer sheet which corresponds to that of each conclusion blacken space

- **A** if you believe that this conclusion is the *most* acceptable of the three conclusions stated.
- **B** if you believe that this conclusion is the *least* acceptable of the three conclusions stated.
- **C** if you believe that this conclusion is neither the most acceptable nor the least acceptable of the three conclusions.

23. One should hesitate to accept the hypothesis since no explanation is given with respect to why the carbon dioxide influences the rate of breathing. This aspect of the matter is worth investigating.

24. The experiment shows that decrease of oxygen is less potent a factor in controlling the rate of breathing than carbon dioxide.

25. The hypothesis can only tentatively be accepted until the effect of decreasing the concentration of carbon dioxide is compared with decreasing the concentration of oxygen.

Discussion: Items 23, 24, and 25 are considered as primarily involving analysis because the selection of an appropriate response depends, first, on analyzing the report of the experiment; second, on analyzing the implications of the conclusion; and finally relating the two. Notice that the instructions require a comparison of the appropriateness of the three conclusions so that the task also has elements of evaluation in it. The expected answer to Item 23 is B on the grounds that the hypothesis and the experiments are aimed at assessing relative significance and not at explanation. Item 24 is considered as the most acceptable answer, although this conclusion might be regarded as somewhat more tentative than the statement of it suggests. The expected answer to item 25 is C. This is perhaps a debatable characterization, but is based on the consideration that although tentative acceptance of the hypothesis is in order, the demurrer is somewhat inappropriate because the specified comparison has already been taken into account in at least some measure.

5.00 Synthesis

5.10 Production of a Unique Communication

5.20 Production of a plan, or proposed Set of Operations

26. Write a 500-word essay on *one* of the following:

1. Eugenic sterilization should be legalized in all forty-eight states of the United States because—

2. Eugenic sterilization should be made illegal in every state in the United States because—

Discussion: The task of writing a 500-word essay involves the development of a plan of organization or outline for the essay incorporating the main points to be made and the evidence or reasons for them. The task also involves the production of a unique communication whereby the student conveys his feelings, ideas, and points of view about the topic proposed.

5.30 Derivation of a Set of Abstract Relations

27. A housing concern has made some experiments on methods of heating houses. A room was constructed with walls that could be heated or refrigerated at the same time that air of any temperature was being circulated through the room. Several individuals were asked to record their sensations as the conditions were varied as follows:[1]

Trial	Wall Temperature	Air Temperature	Sensations
1	85°	85°	Uncomfortably hot
2	85°	50°	Uncomfortably hot
3	70°	85°	Comfortable
4	70°	70°	Comfortable
5	70°	50°	Comfortable
6	50°	50°	Very cold
7	50°	70°	Uncomfortably cold
8	50°	85°	Cold

How can you explain the sensation of "coldness" by a person in a room where the air temperature is 85° and the wall temperature is 50° (all temperatures Fahrenheit)? Consider the following questions and organize your thinking under the outline given below.

- **A.** Make all the suggestions you can which you believe will explain why a person is cold in a room where the air temperature is 85° and the wall temperature is 50°. Give your reasons as to why you believe each of these suggestions will explain the phenomenon.
- **B.** What kinds of evidence would you want to collect which would enable you to decide among your suggested hypothesis?
- **C.** Now go over the suggestions which you have made above and select the one which you believe to be the "best" explanation and give your reasons for your selection.

Discussion: This problem involves the formulation of a number of hypotheses and the suggestion of the kinds of evidence which would facilitate a choice among them. This process is regarded as the development of one or more abstract relations aimed at explaining a particular phenomenon.

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[1] Adapted from *The Measurement of Understanding,* The Forty-Fifth Yearbook, Part I. Prepared by the National Society for the Study of Education. Chicago: University of Chicago Press, 1946. P. 118.

6.00 Evaluation

6.10 Judgments in Terms of Internal Evidence

(Students had been asked to read *Arrowsmith*, by Sinclair Lewis, which describes the role played by several people in relation to the performance of a scientific experiment.)

28. Write an essay of 600 to 800 words on *one* of the following:
    1. *Arrowsmith* presents a realistic and accurate picture of research scientists and of how research is accomplished.
    2. *Arrowsmith* betrays on the part of the author a lack of understanding of science and of the way in which scientists work.

Discussion: In this problem the student is expected to draw on a wide range of evidence internal to the book and to organize it so as to substantiate the particular point of view he has chosen to present. The issue is simply whether the book is or is not a valid picture of scientific research procedures and attitudes. A strong argument can be made either way so it is the strength of the argument and its basis in specific evidence internal to the book which is to be judged in grading the essay.

6.20 Judgments in Terms of External Criteria

(Students had been asked to read an excerpt from *Arrowsmith* describing the role played by several people in relation to the performance of a scientific experiment.)

29. Of the following people mentioned in this excerpt the ablest scientist was

    A. Martin. B. Gottlieb. C. Tubbs.
    D. Leora. E. McGurk.

30. Of the following people mentioned in this excerpt the one who violated most attributes of a scientist was

    A. Tubbs. B. D'Herelle. C. Gottlieb.
    D. Terry Wickett. E. Martin.

Discussion: These items assume that the student has developed an understanding of the nature of scientific attitude and method to the point where this understanding constitutes a set of criteria against which the student can judge the relative merit of these characters from *Arrowsmith*. The intended answers are B for item 29 and A for item 30.

The Use of the Folio

Various Specific Adaptations

The immediately obvious use of a set of test items is that of making tests. Many man-hours of energy are spent each year by teachers preparing and reading examination questions. An increasing number of individuals spend hours in carefully planning an examination and in carefully working out objective test items designed to get at particular educational objectives. Although few teachers use exactly the same questions from semester to semester, the repetition of the same idea and almost identical test items (noted earlier in discussing the accumulation of items for this folio) indicates that there is much duplication in the tests from one time to another and from one institution to another. The major purpose of this folio is to provide a large pool of items from which instructors may make selections, with a considerable saving of time on their part and with the assurance in most cases that a somewhat better set of questions testing a particular concept or objective will have been obtained than if the instructor wrote all items himself.

It will be the rare case when a teacher can find in this folio of items a set of items which will make up a complete test adequately covering all phases of a particular course. It is to be expected that in most courses there will be points of emphasis which will not be covered by folio items but which will demand inclusion in an examination. In most cases an instructor will find that he must supplement questions from this folio with additional questions of his own. To assure that this is done with some care and that a balanced examination is achieved, a plan should be prepared which makes explicit the total number of questions, the particular topics to be covered, and the objectives to be sampled. As items are selected from the folio to cover many of these points, the various specifications can be checked off. It then becomes immediately evident just what topics and objectives are not covered by items from the folio so that the instructor may undertake to produce the additional items needed to balance out the examination.

Just as it is improbable that very many individuals will find it either possible or desirable to make up a complete examination by taking items from this folio, so it is entirely possible that few individuals will find themselves completely satisfied with the precise wording of any large number of items which they may wish to use. Although most of these items have been somewhat more carefully edited than is true for many objective test items, no prospective user of them should feel any compunctions about making changes which make the item more satisfactory for use in his particular situation. Such changes should not be made without reflection, for it is entirely possible that changes may actually destroy much of the significance of the item.

The recommended use of this folio in making up local tests would involve selection of a number of items from this folio and the rounding out of these selections with additional items written by the instructor or taken from other sources, perhaps prior examinations used in the course. For the individual who has done little item writing, the items given in this folio may readily serve as models. The teacher who views the questions as models may be intrigued by the various forms of items which are exhibited, but he should not be led to feel that it is desirable in making up a test to use all of the varieties of objective test forms which are to be found in the folio. As has been mentioned earlier, the particular form chosen for an item should not be a primary concern. The structure should not be so complicated as to overshadow the ability which is being tested. In most cases, the actual form of a test item is determined by its adaptability to the particular objective being tested. If machine scoring forms are used, further restrictions on item forms may be involved. Otherwise the structure of items should be incidental and unobtrusive.

The items included in this folio fall much more heavily under the earlier points of the taxonomy. Apparently few questions involving the more complex objectives of the taxonomy are to be found in examinations. If we recognize that objective test questions testing such abilities are difficult to write and that these questions are also time-consuming for students, we need not be surprised at their infrequency. Although it is easy to write essay questions which, by their use of such words as analyze, synthesize, and evaluate, seem to require classification at the higher ranges of the taxonomy, there is no assurance that student responses will be at the level implied by the question. In any case, the proportion of items found under the various objectives is to be regarded more as a reflection of present practice than an ideal one. However, in selecting items for inclusion, so many purely recall questions were discarded that the folio as a whole probably includes fewer purely knowledge items than most of the tests from which items were drawn.

The major consideration in using these items as models should be that of the relating of the items to the testing of various objectives. Careful study of a group of items relating to a particular objective should help in developing new items dealing with the same objective. The instructor who is concerned with a certain objective in his course, and who finds that the items embodying that particular objective are not entirely suitable for his purposes, may receive some help from studying items on other objectives which seem to him to have somewhat similar behavioral implications. Although the folio has been seen as providing suggestions and models for item writing, no attempt has been made to present the finer points of item writing. An individual who plans to write his own items should refer to some discussion of suggestions for writing of test items and some lists of characteristics of good test items such as that embraced in references 16 and 21 in the bibliography given in Part C, Section III. A few sample instructions to students, provided in Part B of Section III, may be helpful in suggesting the type of general directions needed at the beginning of a test.

In the title of this folio we have chosen to use the words "Questions and Problems" rather than the phrase "Test Items." One major reason for this choice of words was a feeling that too often test items are regarded as useful in tests but having no value for other purposes. A test exercise which requires the exhibition of a certain kind of ability in order to satisfactorily answer it is not only a test item but it is a problem, a question, or an exercise which requires that the student exert this particular ability. Although physical analogies to mental activity are always dubious, one may be helpful in making a point. A person who wants to win tennis tournaments prepares for them by playing tennis. The practice or the experience in which he engages in order to develop this skill is not essentially different from the situation in which the skill is finally exhibited. He may practice serves, drives, and memorize rules, but he engages in many practice sets identical in every way with the formal tournament situation excepting only for the pressure involved in the latter. All too often educational objectives which require some thought, originality, and creativity on the part of students are ignored in practice because of the passive behavior of reading, listening, and repeating of instructors' and textbook statements which characterize so much of our educational activity. Students need more experience in tackling problems on which the answer is not given and cannot be easily found by reference to a single textbook.

If proper student motivation is to be derived from such use of problems, it is desirable that each student be required to make a decision regarding his concept of the right answer before any discussion of it is entered upon by the class. The reason for this is that it is easy for a student to rationalize himself into believing that the answer finally agreed upon as right is the one that he would have selected in the first place. There is nothing quite like finding that one's decision is wrong and understanding why it is wrong, to make it clear to a person that he has not mastered the ability or the content involved in a particular exercise. Furthermore, the fact that the students differ among themselves in the answer which they have selected is considerable stimulation to the discussion. A show of hands can be had on how many students think that the first response to an item is correct and one of those taking this position may be asked to explain why he so believes. The same may be done with other alternatives either stated or proposed by students until agreement is reached or the basis for differing opinions is made clear. Several test items may be selected and assigned as homework. In such cases the student may be asked not only to make a decision as to what he believes to be the right answer to an objective test question but also to write a paragraph in which he sets forth his reasons for this being correct, including reasons why the alternative answers are not correct or at least are not as satisfactory. Such assignments can also be the basis for discussion in the class on the following day in much the same way as has been suggested above. Some teachers like to use this technique of combining objective and essay responses in their tests.

The more able students in class are generally characterized by a degree of intellectual curiosity which will lead them to enjoy problem-type situations in which they can apply some of the knowledge which they have gained. Some of the more difficult problem situations given in this folio might be selected and passed out to these able students with the idea that they would attempt to answer these and perhaps turn their answers in separately to the instructor.

Many class reviews are characterized by long reading assignments (largely ignored by the students as repetitions of things already done) and by the hasty enumeration of major points by the instructor (avidly copied by the students). A review can be pointed up by a careful selection of test items covering some of the major points and abilities which have been involved. A student may then be asked to work these in much the same way as he would in a test situation, except that he would have the opportunity when he is faced with difficulty to refer to his text, syllabus, and other materials in order to determine just what the answer is. In using test items for such review purposes it is necessary to emphasize repeatedly that the particular point of knowledge or content of the item is not as important as the ability or the general area of knowledge sampled by the item.

The preceding suggestions as to uses of items in this folio are only illustrative practices which have been successfully used by teachers. Many other possibilities may develop. It is hardly necessary to say that anyone who finds a worth-while way of using these materials should feel free to do so.

Cautions

There are some cautions which need to be kept in mind in using the folio so that its value is not destroyed or that its use does not become harmful to the students. The most serious misuse has already been implied in the preceding comments. The value of the folio will have been lost and actual harm will have been done if any group of students in a class where this folio is used decide that they can assure themselves top grades in the course by obtaining a copy of the folio, or of the correct answers to all items in it, and memorizing these. This folio of test items was not intended to be placed in the hands of undergraduate students. Rather the folio is a resource to be used by instructors from which they may draw materials as they wish to use them in their classes. Perhaps no particular mention should be made of the test folio as a source of items, for, to the occasional unprincipled student, even the existence of such a folio of items may become a challenge to obtain it. This problem is a commonplace one to all teachers and perhaps the warning is scarcely needed.

There are other cautions which should be obvious to the teacher whether or not he draws upon such a resource as this test item folio, but which may be forgotten in the rush of putting together an examination. The suitability of questions for a particular course is a matter always foremost in the minds of teachers. A weakness of many examinations is that the test items are so definitely limited to the particular test and teacher that they may almost be unintelligible to other students who have taken work in the area. While it is unfair to students to give a test which has been designed for other circumstances, the teacher who never can find questions or test items constructed by anyone else which are entirely suitable for use in his course may, by this very evidence, be demonstrating that he is entirely too provincial or individualistic in his presentation. His insistence that this is his privilege may be placed in question on the grounds that his students are not always going to answer his questions. The limited approach of the instructor in such cases may turn out to be a real handicap to his students. Although it is not expected that all items reproduced in this folio will be equally suitable to all courses involving the same topic or same objective, some of them should be entirely appropriate and others should be suggestive of ways to broaden the scope both of testing and instruction.

There is no test item which is good for all circumstances, all teachers, and all courses. The fact that a test item appears under a certain content heading and is keyed into an objective does not necessarily mean that this particular ability is being sampled for a given class or for every individual in that class. Furthermore, if students have had no experience with regard to some of the objectives represented in this folio, an item (no matter how good it may be) will probably not function very well for such students. The excellence of an item as a basis for discriminating among students is always relative to educational experience that the students have had.

The excellence of the individual items varies considerably from both a testing and a scientific view-point. The extent of the task prevented thorough professional analysis beyond the rough screening which the editors were able to employ. Many users will be able to improve the quality of the items by re-phrasing as well as by adapting them to their particular purposes.

One final word of caution with regard to the use of essay material. We have previously noted that essay questions are apt to be so closely related to the particular course and even to the personality of the teacher that they have little value for anyone else. Certainly the essay type of question is rather inadequately represented in this folio. Those which are found here should be considered as suggestive of ways of phrasing questions rather than as questions which should be readily used with other students. Well thought-out essay questions are no easier to develop than good objective test questions. The person who thinks through an essay question carefully will try to foresee in some detail just what may be expected from the student in the way of an answer and then decide whether his question has been so stated that it is reasonable to expect that these various factors will be brought into the response by the student. With many an essay question one cannot easily tell what the writer has had in mind. This indefiniteness and the resulting bewilderment of a student often give rise to answers far less adequate than the teacher had expected. Indeed, different students may be responding to essentially different tasks.

There are certain kinds of ability which cannot be adequately tested except in situations where the student must formulate his own ideas, organize, and present them. At best, in the objective test situation the student is making a selection from responses placed before him. While this is not an unrealistic situation at all, it is not typical of all of the situations in which we expect people to be able to function adequately. The objective test question imposes a fairly rigid framework within the limits of which the respondent must operate, thereby greatly easing the problem of grading. The problem of the essay question is to impose sufficient strictures on the response of the person so that the matter of grading can be reasonably objective and yet, at the same time, give to the individual opportunity for showing his own ability to recall, organize, and utilize his knowledge in dealing with a situation which is new to him. While this folio is weighted in the direction of objective test items, this is not an indication that essay materials are devaluated. On the contrary, there can be no doubt that either evaluation or instruction based entirely on a multiple choice response from students is grossly inadequate.

SECTION II

Questions and Problems

THE QUESTIONS and problems which follow have been arranged as nearly as possible under some thirty subject matter headings in each of the two major subdivisions: II A. Biological Science, and II B. Physical Science. Within each subject-matter category the items have been further ordered in sequence as to the objectives they embody. Thus, in the first category, "Perception and Symbolization," the sequence of items by objectives is found to be as follows: 1.10, 1.20, 2.20, and 3.00. Some of the subsequent categories are larger in scope and contain a more complete representation of the gamut of objectives. The objective tested by each item is indicated by an objective reference number in parentheses under the item number.

A final category under Subdivision I, labelled "Unclassified," includes items which could not easily be assigned to a single subject-matter category, and also a set of items that do not lend themselves, without further adaptation, to machine scoring. These items may be useful in informal quizzes with small groups of students.

The condensed version of the taxonomy of objectives is found in Appendix A. For convenience in reference, and without definition, the major heads of the taxonomy are reproduced here.

1.00 Knowledge

1.10 Knowledge of Specifics
1.20 Knowledge of Ways and Means of Dealing with Specifics
1.30 Knowledge of the Universals and Abstractions in a Field

2.00 Comprehension

2.10 Translation
2.20 Interpretation
2.30 Extrapolation

3.00 Application

4.00 Analysis

4.10 Analysis of Elements
4.20 Analysis of Relationships
4.30 Analysis of Organizational Principles

5.00 Synthesis

5.10 Production of a Unique Communication
5.20 Production of a Plan, or Proposed Set of Objectives
5.30 Derivation of a Set of Abstract Relations

6.00 Evaluation

6.10 Judgments in Terms of Internal Evidence
6.20 Judgments in Terms of External Criteria

A. Biological Science Content Categories

1. *Perception and Symbolization*

PERCEPTION AND SYMBOLIZATION

1. Which of the following marks the beginning of man's
(1.10) unique learning process; that is, as it is distinguished from the learning of other animals?

- **A.** Inquisitiveness, expressed in symbols, about the real environment.
- **B.** Perception of objects by means of the senses.
- **C.** Reaction to real objects in the environment.
- **D.** Adjustment of operational behavior to "signs" in the immediate environment.
- **E.** Curiosity about actual objects in the environment.

2. Perception by means of sign is *not* affected noticeably
(1.10) by which one of the following?

- **A.** Color of objects.
- **B.** Duration of stimulus on retina.
- **C.** Intensity of light.
- **D.** Color of the iris of a normal pigmented individual.
- **E.** Distance of object from observer.

3. A three-dimensional concept of material being viewed
(1.10) under high power of a microscope can be obtained by

- **A.** changing the intensity of the light entering the tube.
- **B.** moving the slide back and forth.
- **C.** turning the fine adjustment knob back and forth.
- **D.** focusing your own eye upon the upper, then on the lower regions of the material being examined.
- **E.** rotating the ocular.

4. Man is superior to all other animals in which of the
(1.10) following?

- **A.** Keenness of sense of sight.
- **B.** Keenness of sense of smell.
- **C.** Ability to use substitutes for direct experience.
- **D.** Fleetness on foot. **E.** All of the above.

5. Analysis of a new situation in terms of an old one can
(1.10) perhaps best be done by

- **A.** largely disregarding the old or known and concentrating on the new or unknown.
- **B.** first formulating a conclusion, then gathering facts to prove that it is true.
- **C.** formulating hypotheses as to similarities and dissimilarities and testing them.
- **D.** selecting from the data those facts which prove the point, manipulating these facts to best advantage, and disregarding the rest.
- **E.** none of the above.

6. Four of the following constitute advantages that may
(1.10) arise from the use of symbolism. Which one is a *disadvantage?*

- **A.** The symbol makes unnecessary the manipulation of the object it represents.
- **B.** The symbol may become completely dissociated from the object it represents.
- **C.** Information can be stored.
- **D.** Experience can be gained vicariously.
- **E.** A cultural heritage becomes a possibility.

7. If a perfectly spherical cell, one unit in diameter, were
(1.20) to divide into two similar perfectly spherical daughter cells, what would be the diameter of each of the two daughter cells?

- **A.** About ½ unit **B.** About ⅔ unit
- **C.** About ¾ unit **D.** About ⅘ unit
- **E.** About ⅝ unit

8. If a paramecium is approximately one seventh of the
(1.20) diameter of the low power field, what is its actual size?

- **A.** About 100 microns **B.** About 200 microns
- **C.** About 300 microns **D.** About 0.001 inch
- **E.** About 0.001 millimeter

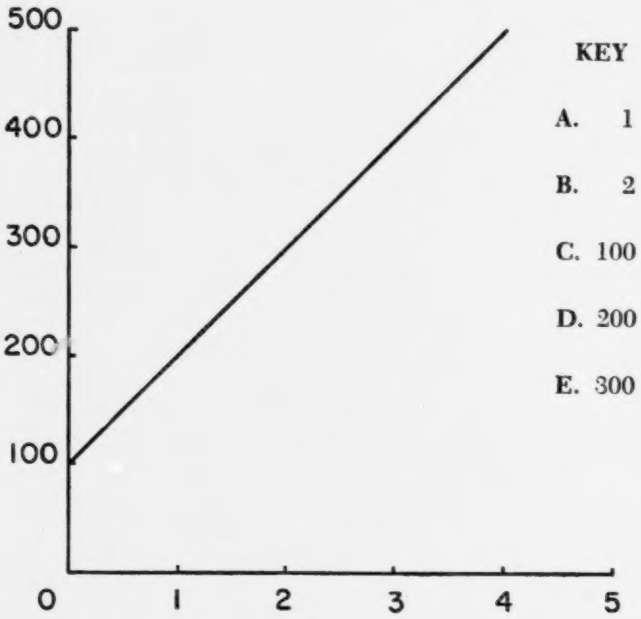
9. A cell which is 25 microns in diameter is
(1.20)

- **A.** larger than **B.** smaller than
- **C.** approximately the same size as a similar cell which is 1/2500 inch in diameter.

10. Which one of the following symbolic relationships is *not* logical in relation to the remaining four?

A. $AB = C$ **B.** $A = \frac{C}{B}$ **C.** $B = \frac{C}{B}$
D. $AC = B$ **E.** $BA = C$

For items 11 - 13 use the data of the following graph and key:
(2.20)



11. What is the value of the slope of the line?

12. When "Y" is 200, what is the value of "X"?

13. What is the value of "b"?

14. When an architect draws a set of plans for a building,
(3.00) such as this one you are now occupying, he employs which of the following?

- **A.** Operational behavior in terms of objective "signs."
- **B.** Substitutes for direct experience.
- **C.** Immediate perception of a reaction to the object.
- **D.** Direct experience trial and error.
- **E.** None of the above.

15. Which of the following represents complete dissociation
(3.00) of symbolism from reality?

A. A reader engrossed in a novel imagines one of the characters to resemble very closely an individual who lives in the neighborhood.

B. An engineer while designing a bridge checks and rechecks tables giving strengths of materials to be used in the construction of the bridge.

C. An insane person becomes indignant when an observer who restrains him fails to appreciate his imaginary role as parachute jumper off a high precipice.

D. A composer writing a tone poem for symphony orchestra draws upon his previously conditioned mental imagery to recall how various phrases will sound when played by different combinations of instruments.

E. None of the above.

2. *Diffusion and Osmosis*

DIFFUSION AND OSMOSIS

1. Diffusion of one substance through another can usually
(1.10) be *hastened* by one or several of the following means. By which means, however, would diffusion tend to be retarded?

A. Heating **B.** Agitation **C.** Rarefaction
D. Dissolving **E.** Freezing

2. The direction of diffusion is determined primarily by
(1.10)

A. the nature of the diffusing substance
B. the nature of the medium through which these particles are diffusing
C. the size of the diffusing particles
D. more than one of the above
E. none of the above

3. The direction in which a substance moves through a
(1.10) differentially permeable membrane in the process osmosis is most dependent upon the differences in

A. concentration of water molecules
B. relative diffusion rates
C. rate of molecular motion on either side of the membrane
D. affinity of the dissolved substance for water and the cohesive force of water
E. affinity of the dissolved substance for water and the adhesive force of water

4. Which of the following statements constitutes the best
(1.10) definition of osmosis?

A. Selective diffusion of solutions or gases through a differentially permeable membrane
B. The passage of solutes from a region of lesser concentration
C. Simple diffusion
D. A pressure-diminishing phenomenon characteristic of all living organisms
E. The separation of sunlight into the component colors of the spectrum

5. Osmosis can best be described as
(1.10)

A. simple diffusion
B. a pressure-diminishing phenomenon characteristic of all living things
C. the passage of solutes from a region of lesser concentration through a selective membrane to a region of greater concentration
D. the separation of sunlight into the component colors of the spectrum to facilitate photosynthesis
E. diffusion of water through a differentially permeable membrane

6. Osmosis can best be described as
(1.10)

A. diffusion of water through a differentially permeable membrane
B. diffusion of a solute throughout every part of a solution
C. a process in which water is raised against gravity in response to the action of atmospheric pressure
D. a process which is altogether unique to living organisms; it cannot occur in an inert system
E. a process which can occur only in the presence of light and an abundant supply of oxygen

7. Much of the water entering an amoeba by osmosis is
(1.10) eliminated by the action of the

A. contractile vacuole **B.** gastric vacuole
C. ectoplasm **D.** cytoplasmic crystals **E.** pseudopodia

8. The particles of which all matter is composed are be-
(1.10) lieved to be

A. moving at the same rate regardless of the mass or physical state of the matter
B. moving at different rates, the differences depending on the quantity or mass of the matter
C. moving at different rates, the differences depending on the physical state and temperature of the matter
D. stationary and immovable **E.** none of the above

9. The process by which materials enter and leave cells of
(1.10) an organism is known as

A. transportation **B.** transpiration **C.** absorption
D. diffusion **E.** inhibition

10. How does oxygen enter the cell of a flat worm (for
(1.10) example a planarian)?

A. By osmosis **B.** By diffusion **C.** By absorption
D. By respiration **E.** Through the lungs

11. Four of the following statements about diffusion are
(1.10) true. Which one is false?

A. Substances diffuse from regions of their greater concentration to regions of their lesser concentration.
B. Small particles will diffuse far more readily than large particles.
C. Diffusion occurs more readily in a gas than in a liquid.
D. Diffusion is more readily visible in a liquid than in a gas.
E. Diffusion is possible in all directions, except against gravity.

For items 12 - 15 select the best response from the following key.

KEY

A. Diffusion **B.** Osmosis **C.** Capillarity
D. Absorption **E.** Transpiration

12. Physical process by which dissolved substances enter the
(1.10) cells of a living organism

13. Process by which water enters and/or leaves the cells
(1.10) of a living organism

14. Process by which the wastes from the activities of cells
(1.10) in large trees would be eliminated

15. Process by which dissolved substances enter and leave
(1.10) the small blood vessels in animals

16. Osmosis is the term applied to the
(1.10)

A. diffusion of substances from one place to another
B. passing of dissolved substances through a filter
C. passing of a liquid through a completely permeable membrane
D. passing of a liquid through a differentially permeable membrane

17. Which the following statements concerning osmosis is
(1.10) most nearly applicable?

A. Osmosis is essentially a diffusion process.
B. Osmosis is essentially a process involving capillary action.

C. Osmosis works on a principle similar to that of the siphon.
D. Osmosis functions only in living organisms.
E. Osmosis functions only in the presence of light.

18. (1.10) In the following pair, blacken space 1 if the first element of the pair is definitely greater than the second; space 2 if the second is definitely greater than the first; and space 3 if the two are approximately equal.

A. Movement of water between a cell and a hypertonic solution
B. Movement of water between a cell and an isotonic solution

19. (1.10) Roothairs take up water from the soil chiefly by

A. capillarity **B.** plasmolysis **C.** translocation
D. osmosis **E.** transpiration

20. (1.10) Water moves from the soil to the first living cells of a normal root because

A. it is needed to replace what is inevitably lost by evaporation from the upper parts of the plant
B. dissolved substances are in higher concentration in the root cells than in the soil water
C. the cell wall is permeable to water
D. of the secretory action of the living cells
E. it is needed for photosynthesis

21. (1.10) The basic mechanism involved in the transport of substances in living tissue is

A. osmosis **B.** internal movement of protoplasm
C. attraction of molecules **D.** inertia **E.** diffusion

22. (1.10) Osmosis is

A. the diffusion of a colored solution through a clear liquid
B. a special type of one-way diffusion through a semipermeable membrane
C. the result of putting pressure on a solution

23. (1.10) The process by which gases enter the cells, are utilized by them, and leave the organism is called

A. absorption **B.** excretion **C.** expiration
D. respiration **E.** breathing

24. (1.10) The source of the energy producing diffusion is

A. the gravitational attraction between masses
B. the random movement of molecules
C. the electrical attraction between charges of opposite sign
D. derived from the chemical potential energy of glucose
E. chemical affinity of certain substances for each other

25. (1.20) A certain freshwater protozoan has a contractile vacuole. If a small amount of salt is added to the medium in which the animal lives, the quantity of water expelled by the contractile vacuole in a given time would be

A. greater than **B.** less than **C.** same as

the quantity of water expelled by the vacuole in the same time in the original medium

26. (1.20) Osmosis occurs whenever

A. there is a solution involving two substances of different molecular weights
B. one substance is dissolved in another, with a membrane between two parts of the solution
C. the concentration of solute on one side of a membrane is different from the concentration of solute on the other side of the membrane
D. a membrane separates two regions of a fluid
E. a membrane permeable to solvent but not to solute separates two differently concentrated regions of the solvent

27. (1.20) A normal (turgid) *Elodea* leaf is placed in tap water.

A. The cytoplasm will pull away from the cell walls.
B. The cell walls will burst.
C. The cell walls will shrink, wrinkling to give the appearance of a many-pointed star.
D. The streaming of chloroplasts will cease, but otherwise the cells will appear normal.
E. The cells will maintain their usual appearance.

28. (1.20) When an amoeba is placed in water slightly more hypotonic than its natural habitat, one would expect

A. it to burst **B.** it to shrink
C. its contractile vacuole to empty slightly more frequently
D. its contractile vacuole to empty slightly less frequently
E. no change from its appearance or behavior in its natural habitat

29. (1.30) Which of the following is a broad *principle* that is fundamental to the organism's utilization of matter and energy?

A. Only substances in solution can diffuse through the cell membrane of the protoplasm.
B. Diffusion is the process whereby particles scatter from a region of lesser concentration to one of greater concentration.
C. The hydrolyzing process that occurs in the alimentary tract is known as digestion.
D. An enzyme is an organic catalyst.
E. None of the above is a principle.

30. (2.10) An osmotic sense

A. kinesthetic **B.** equilibrium **C.** thirst
D. hunger **E.** optic

31. (2.20) Which one of the following is an example of diffusion?

A. The flow of water in a river
B. Movement of traffic on a busy highway
C. Raindrops falling from clouds
D. Equal distribution of sugar in a dry cake mix
E. Apparent disappearance of smoke from a candle

32. (2.20) Molecules of dye can move at the rate of 200 miles per hour but they may actually require weeks to diffuse an inch up a tube of water. This phenomenon can be accounted for

A. because the dye molecules move upward slowly due to the pull of gravity
B. because other molecules impede upward movement of the dye molecules by constantly changing the direction of their movements
C. because the walls of the tube retard diffusion of the dye
D. by more than one of the above
E. by none of the above

33. Red blood cells will burst if placed in a 0.9% colloidal
(3.00) suspension of proteins but will retain the normal condition in a 0.9% sodium chloride solution. This provides evidence that red blood cells contain

A. less than 0.9% sodium chloride
B. more than 0.9% sodium chloride
C. less than 0.9% colloidal protein
D. more than 0.9% colloidal protein
E. antigens capable of dispersing colloidal suspensions

34. Of the following substances, the one *least* likely to enter
(3.00) a typical cell in significant amounts by the process of diffusion is

A. oxygen **B.** glycerol **C.** nitrate ion
D. a protein **E.** glucose

35. A chamber is divided into left and right halves by a
(3.00) membrane which is permeable to water molecules but not to glucose molecules. The left side is half filled by a 2% glucose solution, while the right side is filled to the same level by a 3% glucose solution.

A. Water moves across the membrane, and only toward the left.
B. Water moves across the membrane, equally in both directions.
C. Glucose moves across the membrane, equally in both directions.
D. Water moves in both directions, but mainly to the left.
E. Water moves in both directions, but mainly to the right.

36. Osmosis is the principle on which all *but one* of the
(3.00) following largely depend. That one is

A. preservation of fruit by the use of sugar
B. preservation of fish by the use of salt
C. preservation of food by the cold pack process
D. the harmful action of sea water in the digestive tract
E. the absorption of water by a root

37. People adrift at sea may perish of thirst even though
(3.00) there is water all around them. On the basis of a common principle in biology, why may drinking sea water in an attempt to quench thirst be disastrous?

A. Salts in the sea water are likely to damage the wall of the stomach by eroding it.
B. Salt will likely pass from the body cells into the intestine to mingle with the salt of the sea water there.
C. The blood, which is already deficient in water, will likely lose more water to the intestine which contains the salt sea water.
D. The salt sea water will probably pass very quickly from the intestine to the kidneys, overburdening them.
E. Sea water contains many disease-producing microorganisms which are almost certain to cause death.

38. If a substance is to enter a cell continuously by the
(3.00) process of diffusion, it must be true that

A. the substance is always more concentrated in the environment than inside the cell
B. a greater amount of carbon dioxide is evolved when the substance is entering than when the substance is not entering
C. the substance does not enter the cell when the cell is an oxygen-poor environment
D. the substance has a higher molecular weight than some other substance known to enter the cell
E. the substance can diffuse through air

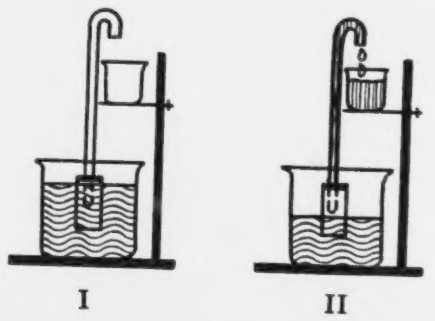
39. The net osmotic difference would be greatest between
(3.00) cytoplasm and

A. 0.9% NaCl solution **B.** pond water
C. distilled water **D.** Ringer's solution
E. blood or sap

40. The shrinkage of the cytoplasm of a cell in an *Elodea*
(3.00) leaf placed in a concentrated salt solution is due to

A. the increase in cytoplasmic concentration of the salt absorbed from the external salt solution
B. an increase in the rate of entry of water molecules through the cell wall from the external solution
C. the lower concentration of water outside the plasma membrane than within the cytoplasm
D. the excessive conversion of glucose to polysaccharides stimulated by the increased salt in the cytoplasm
E. the tendency of chloroplasts to adhere to each other, rather than disperse through the cytoplasm

After each item number on the answer sheet, blacken the *one* lettered space which designates the correct answer.



The device illustrated in the diagrams above consists of a thimble shaped (porcelain) tube filled with molasses (sugar consisting of relatively large molecules dispersed among water molecules). A rubber stopper pierced by a thin glass tube closes the top of the thimble, which is placed in a beaker full of water and is held in place with a clamp. Diagram I illustrates the beginning of the experiment, while diagram II shows the conditions prevailing after the passing of several hours.

41. The passage of water molecules through the wall of the
(4.20) thimble results from

A. a force in the thimble which is pushing the molecules
B. air pressure in the beaker which is pushing the molecules
C. a difference in the concentration of the water in the beaker and in the thimble
D. the effect of gravity **E.** capillarity

42. The passage of water is not equal in both directions,
(4.20) because

A. the water molecules can pass through the thimble, but the sugar molecules cannot

B. the sugar molecules can pass through the thimble, but the water molecules cannot
C. both sugar and water molecules are moving into and out of the thimble
D. neither sugar nor water molecules are moving
E. water is moving for a limited time followed by a movement of sugar for a limited time

43. This experiment is illustrative of the phenomena of
(4.20)

A. transpiration **B.** translocation
C. capillarity **D.** osmosis

44. The above phenomena may be further illustrated by
(4.20) placing a sliced piece of potato in cold water. After several hours, examination reveals the piece of potato to be very stiff and hard. This occurs because

A. new chemical substances have formed in the potato
B. water has passed from the cells of the potato into the surrounding water, therefore materials have condensed to form solid particles
C. there is a precipitation of Ca salts in the potato
D. water has passed from the surrounding medium into the potato cells to produce turgor
E. there is an additional formation of cellulose in the cell walls

45. Another slice of potato is placed in a salt solution and
(4.20) after several hours it becomes very limp, soft, and spongy. This occurs because

A. the cellulose in the cell walls of the plant has broken down
B. water passes from the potato cells into the salt solution
C. the salt solution causes a breakdown of the salts formed in the potato cells
D. more water is passing into the potato, therefore the potato becomes soft
E. the cells of the potato are digested by the salt water

Items 46 to 55 refer to the situation represented by the U-tube.

KEY

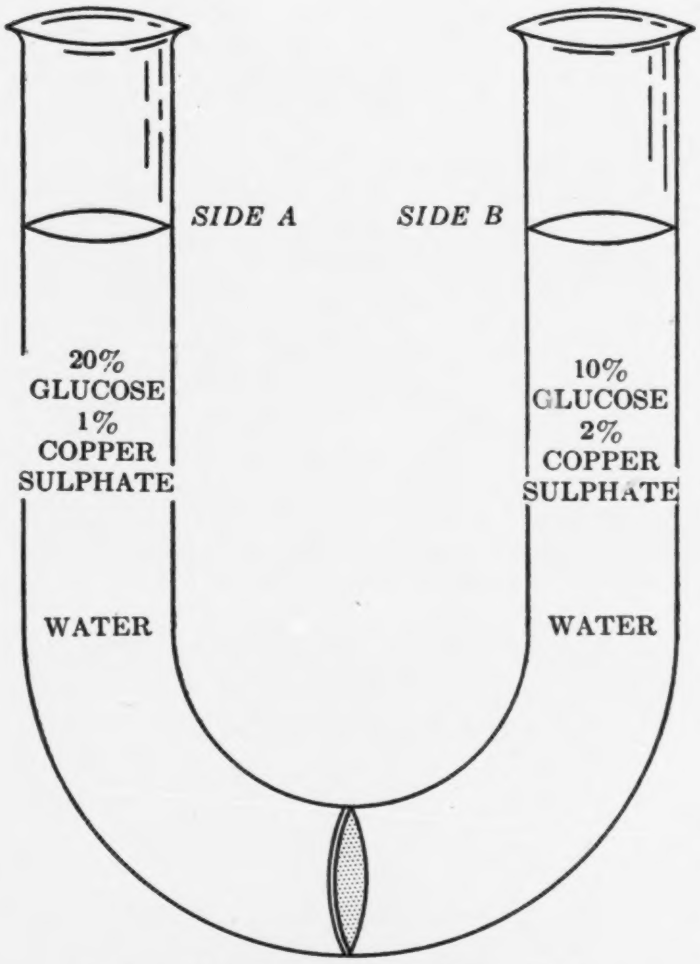
For the items select from the following key the most appropriate phrase.

A. Both the *statement* and the *reason* are *true*.
B. The *statement* is *true* but the *reason* is *false*.
C. The *statement* is *false* but the *reason* is an *accepted fact* or principle having no bearing upon the statement.
D. Both the *statement* and the *reason* are *false*.

46. The glucose solution on side B will become less con-
(4.20) centrated and that on side A more concentrated *because* a substance tends to diffuse from a less concentrated region to one of greater concentration.

47. The copper sulphate solution will become more con-
(4.20) centrated on side A and less so on side B *because* the copper sulphate solution will pass through the membrane from a region of greater concentration of copper sulphate to one of lesser concentration.

48. The glucose solution will become more concentrated on
(4.20) side B and less concentrated on side A *because* the glucose will diffuse through the membrane from a region of greater concentration to one of lesser concentration.



MEMBRANE PERMEABLE TO WATER
AND TO COPPER SULPHATE BUT
NOT PERMEABLE TO GLUCOSE

At the beginning of the experiment the solutions in the two arms of the U-tube are as pictured. They are separated at the bottom of the tube by a differentially permeable membrane. The volumes on either side of the tube are the same and thus the level of the liquid is at the same height in both arms.

The membrane is permeable to water and to copper sulphate ($CuSO_4$) but *not* to *glucose sugar*.

The apparatus is allowed to stand for a number of days.

49. The water level will rise on side A *because* the *water*
(4.20) (not the substances in it) on that side in the beginning of the experiment was less concentrated than that on side B.

50. The glucose solution on side A will become less concen-
(4.20) trated and that on side B more concentrated *because* water will pass from side B to A thus diluting side A.

51. The copper sulphate solution will become more con-
(4.20) centrated on side B and less concentrated on side A *because* substances tend to diffuse from a region where the water is purer to one where the water is not so pure.

52. There will be no passage of copper sulphate through
(4.20) the membrane *because* dissolved substances will not pass through a differentially permeable membrane.

53. The passage of water through the membrane in this (4.20) case is an example of osmosis *because* osmosis is defined as the passage of water (or a liquid) through a differentially permeable membrane from a region of greater concentration to one of lesser concentration of water (or liquid).

54. The water level on side B will rise *because* diffusion (4.20) always takes place from a region of greater concentration to one of lesser concentration.

55. The passage of a dissolved substance (or substances) (4.20) through the membrane in this case is an example of osmosis *because* osmosis is defined as the passage of a substance through a differentially permeable membrane from a region of greater concentration to one of lesser concentration.

Items 56-57. Refer to drawings in right hand column.

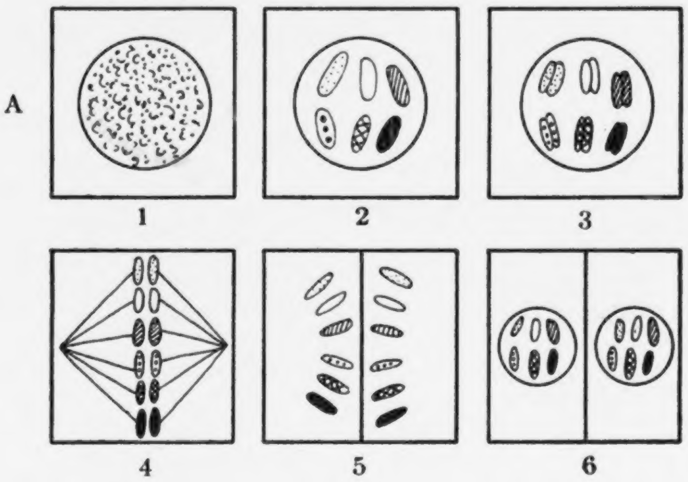
56. The A series of drawings is an example of chromosome behavior in (4.20)

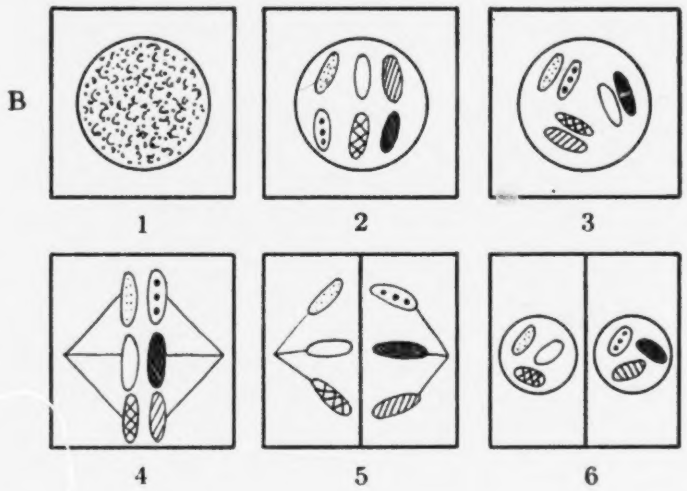
A. normal fertilization in mammals
B. maturation of a germ cell
C. mitosis **D.** pollination **E.** double fertilization

57. The B series of drawings is an example of chromosome behavior in (4.20)

A. normal fertilization in mammals
B. maturation of a germ cell
C. mitosis **D.** pollination **E.** double fertilization

The following drawings refer to items 56 and 57.





3. *Transpiration*

TRANSPIRATION

1. The loss of liquid water from the leaf is called
(1.10)

A. guttation **B.** wilting **C.** evaporation
D. transpiration **E.** plasmolysis

2. The loss of water as water vapor through stomates is
(1.10) known as

A. respiration **B.** expiration **C.** translocation
D. transpiration **E.** transportation

3. Food manufactured in leaves is transported downward
(1.10) to the roots principally through the

A. sieve tubes **B.** cambium **C.** xylem vessels
D. vascular rays **E.** tracheids

4. Cutting away a complete ring of bark from a tree stops
(1.10) the passage of material through the

A. xylem **B.** vessels **C.** phloem
D. tracheids **E.** pith

5. In certain unicellular plants, the structure is such that
(1.10) distribution of food, water, and wastes is taken care of largely by

A. transpiration **B.** assimilation **C.** respiration
D. diffusion **E.** digestion

6. The rise of water to the tops of tall trees is thought to
(1.10) be principally due to

A. root pressure **B.** transpiration pull
C. capillarity **D.** osmotic pressure **E.** adhesion

7. Root pressure is produced principally as a result of
(1.10)

A. osmosis **B.** capillarity **C.** adhesion
D. transpiration **E.** cohesion

8. Soil water first enters a flowering plant through the
(1.10)

A. capillaries **B.** roots **C.** xylem
D. root hairs **E.** cortex

9. The force which is primarily responsible for the rise of
(1.10) water in plant stems is

A. gravity **B.** diffusion **C.** respiration
D. photosynthesis **E.** transpiration

10. Liquids are transported through stems and roots by
(1.10)

A. epidermis **B.** parenchyma cells **C.** cortex
D. vascular bundles **E.** pith

11. Which of the following does *not* aid the ascent of water
(1.10) and mineral solutes through the tree trunk?

A. Diffusion **B.** Capillarity **C.** Transpiration
D. Root pressure **E.** Plasmolysis

12. During the winter months an elm tree
(1.10)

A. stops respiration entirely
B. continues respiration at the same rate as in the summer
C. continues respiration at a slower rate than in the summer
D. continues respiration at a faster rate than in the summer

13. This (see item 12) is partly explained by the fact that
(2.20)

A. photosynthesis cannot take place in the absence of leaves
B. no food is available
C. roots continue to take up food from the soil but at a reduced rate
D. food has been stored up in the tree during the previous summer
E. a fast rate of respiration is necessary to keep the tree from freezing

14. The return of rainfall to the atmosphere before it reaches
(1.10) the sea is accomplished chiefly by

A. transpiration from leaf surfaces
B. evaporation from water surfaces
C. evaporation from soil surfaces
D. discharge of steam and vapor from industry and transportation

15. Evaporation of water from green leaves
(1.10)

A. jeopardizes an animal more than a plant
B. serves an excretory function in both plants and animals
C. regulates temperature to a greater degree in plants than in animals
D. keeps the transpiration stream moving in plants
E. frequently causes heat prostration in animals, especially man

16. Much more water enters the leaf from the stem than is
(1.20) employed in photosynthesis. This serves to

A. provide the photosynthetic tissues with adequate amounts of the respiratory gases
B. provide the photosynthetic tissues with adequate amounts of inorganic salts
C. afford a circulating medium wherein the products of photosynthesis can be conveyed to other parts of the plant
D. screen the photosynthetic tissue from the harmful ultra-violet rays of the sun
E. remove excessive water from the soil which might otherwise "drown" the plant

17. An adequate amount of water is essential for normal
(2.20) plant growth and yet plants lose much water by transpiration. If plants possessed adaptive structures that would prevent entirely the loss of water from leaf surfaces, such structures would

A. prevent the rise of water through the plant stem
B. prevent the diffusion of foods
C. prevent digestion of foods
D. prevent growth of the plant
E. further stimulate plant growth

18. Which of the following has *least* bearing on the rise of
(2.20) fluids in the roots and stems of a vascular plant?

A. The cell wall is freely permeable to many kinds of molecules in solution.
B. In many plants a layer of meristem tissue lies between the phloem and xylem.
C. The size of stomates can be regulated by guard cells in response to changes in atmospheric humidity.

D. Molecules tend to move from regions of higher to lower concentration.
E. Molecules of water at the surfaces of leaf cells escape into the air.

19. (3.00) In addition to the shade provided, what other factor makes a forest cool in the summertime?

A. The conversion of solar energy by the green chlorophyll into stored energy of manufactured food
B. Evaporation of the transpired water vapor
C. Condensation of water in the air upon the plant surfaces
D. The cooling effect of the plant growth processes
E. The absorption of water from the atmosphere by the plant stomates

20. (3.00) One of the principal results of annual leaf-fall in deciduous trees is that

A. respiration ceases entirely until spring
B. winter food-making activities are taken over by the roots
C. the trees obtain their entire food supply from the soil during the winter months
D. water is conserved in the winter
E. the trees survive without food during the dormant winter stage

21. (3.00) The stomata of the leaves are likely to open when

A. the concentration of the cell sap in the guard cells rises above the concentration in adjacent cells
B. the concentration of the cell sap in the guard cells falls belows the concentration in adjacent cells
C. sugar in the guard cells changes to starch
D. light which had been intensely bright becomes substantially subdued, as at sunset
E. photosynthesis ceases and the photosynthetic products are being translocated for storage

22. (3.00) A tree is girdled (ringed) by cutting away a band of bark to the xylem around the trunk. Which of the following is most logical to assume concerning a tree that has been girdled?

A. It dies immediately because the leaves no longer receive food and water from the roots.
B. It dies but not immediately because the leaves do not receive food and water from the roots.
C. It does not die as the removal of the bark does not materially affect the primary functions of the tree.
D. It dies because food can no longer be transported in the medullary rays.
E. It dies but not immediately because the roots starve when their stored food reserves are exhausted.

23. (4.20) The central problem in the above paragraph is:

A. How tall do fir and redwood trees grow?
B. What effect do acids have on a tree trunk?
C. How does water rise in plant stems?
D. What effect does felling of a tree have on its roots?
E. Why does water flow from the stump of a tree?

24. (4.20) The tissue most directly involved in the upward transportation of water in stems is the

A. phloem **B.** xylem **C.** cortex
D. pith **E.** epidermis

(1) The rise of water in stems, such as those of Douglas fir and giant redwoods, involves a vertical distance of more than 300 feet. (2) In 1727 Hales, after cutting down a tree, (3) observed that water continued to rise, under pressure, to the surface of the stump. (4) More than a century later Strasburger first immersed the cut end of the trunk of a 70 foot oak tree in strong acid and then into water. (5) Water still moved to the leaves at the top of the tree. (6) H. H. Dixon (1895) joined the cut end of a leaf-bearing stem to a glass tube filled with water and mercury (Fig. B). (7) Mercury rose to a height of 101 cms. (8) In the absence of the plant stem, but with the tube closed and exhausted the mercury rose to a height of 76 cm. (Fig. A).

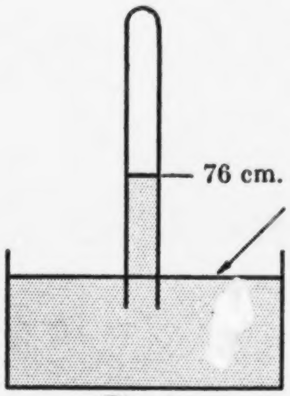


Fig. A

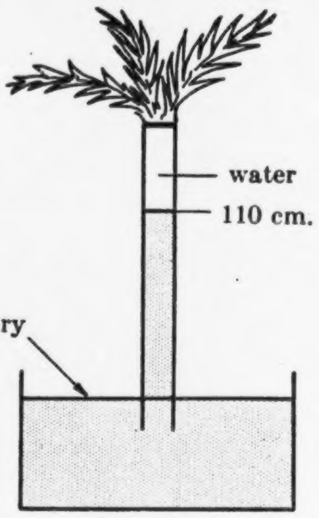


Fig. B

25. (4.20) Statement 1 represents

A. an experimental result **B.** a conclusion
C. an hypothesis based on the results of numerous experiments
D. an assumption since one could not climb that high to measure the tree
E. an observation based on quantitative measurements

26. (4.20) Statements 2, 4, and 6 represent

A. experiments **B.** experimental results
C. conclusions based on experimental results
D. hypotheses **E.** theories

27. (4.20) Statements 3, 5, and 7 represent

A. experiments **B.** experimental results
C. conclusions based on experimental results
D. hypotheses **E.** theories

28. (4.20) Statements 4 and 5 indicate that the rise of water in stems most probably

A. involves the presence of a strong acid
B. depends on the presence of a strong acid
C. does not depend on living tissues of the stem
D. depends on the living tissue of the stem
E. does not involve the roots

29. (4.20) The flow of water up to the stump in observation (3) is most probably due to

A. evaporation of water from the surface of the stump
B. mutual attraction between the molecules of water
C. attraction between the molecules of water and tissues
D. the greater concentration of water in the stem than in the root
E. osmotic pressure

30. The rise of mercury in the tube in figure A is due primarily to the
(4.20)

A. mutual attraction between the mercury molecules
B. attraction between mercury molecules and the glass tube
C. osmotic pressure D. atmospheric pressure
E. evaporation of mercury from the top of the glass tube

31. The cause of the difference between the levels of mercury in the tubes in figures A and B is primarily due to:
(4.20)

A. transpiration pressure caused by evaporation of water from the leaves
B. respiration C. osmotic pressure
D. attraction between the water and mercury molecules
E. atmospheric pressure

32. A factor important in maintaining the water in a stem as an unbroken column of water is
(4.20)

A. atmospheric pressure B. diffusion
C. the mutual attraction of water molecules
D. transpiration E. osmotic pressure

33. The factor responsible for the pressure which causes the flow of water up to the surface of the stump in observation (3) is
(4.20)

A. gravity B. diffusion C. atomic energy
D. capillarity E. cohesion

34. Three well-watered plants with wax paper sealing the dirt in their pots from the atmosphere are placed under three bell jars respectively. The air in the bell jars is dry at the beginning of the experiment. The leaves of the first plant have vaseline over their upper surfaces only. The leaves of the second plant have vaseline over their lower surfaces only and those of the third plant over both the upper and lower surfaces. After 24 hours in the light the inside surface of the bell jar of the
(4.20)

A. first plant showed more moisture than the second or third
B. third plant showed more moisture than the second
C. second plant showed no moisture
D. second plant showed more moisture than the first but not as much as the third
E. first plant showed less moisture than the third plant but more than the second

4. Chemistry
Related to Biological Science

CHEMISTRY RELATED TO BIOLOGICAL SCIENCE

1. (1.10) Many physical properties of protoplasm can be explained by considering it to be

A. a solution **B.** an emulsion
C. a colloidal suspension **D.** a precipitate
E. none of the above

2. (1.10) Which of the following is *not* true of all protein molecules?

A. Each contains all of the essential amino acids.
B. Each can be converted, in large part, into carbohydrate.
C. In man, their breakdown results, eventually, mainly in the formation of urea.
D. On an "ounce-for-ounce" basis, they are less effective than common salts in exerting osmotic pressure across membranes permeable only to water.

3. (1.10) Which of the following is the most complex compound?

A. A protein **B.** An amino acid **C.** A nitrate
D. An inorganic nitrite **E.** Ammonia

4. (1.10) Subdivision of large, complex molecules into their smaller, simpler components is accomplished in the digestive process by a chemical reaction known as

A. condensation **B.** hydrolysis **C.** plasmolysis
D. synthesis **E.** agglutination

5. (1.10) A catalyst is

A. a substance which affects the velocity of a chemical reaction
B. a powerful oxidizing agent
C. a substance that does not take part in a chemical reaction
D. a strong electrolyte
E. the negative pole of an electrolytic cell

6. (1.10) Which one of the following is *not* a compound?

A. Water **B.** Sugar **C.** Hydrogen
D. Salt **E.** Carbon dioxide

7. (1.10) If a substance is changed chemically, it might be expected to exhibit a change in

A. its boiling point **B.** its solubility
C. its miscibility **D.** its viscosity
E. more than one of the above

8. (1.10) The greatest number of different kinds of elements occurs in

A. fats **B.** proteins **C.** starches
D. sugars **E.** minerals

9. (1.10) A naturally-occurring inorganic substance having a definite chemical composition and, as a rule, a definite form and structure is properly called

A. an organic compound **B.** coal
C. a physical property **D.** a mineral
E. a mixture

10. (1.10) The underlying organic substance from which more complex foods are synthesized in the plant is

A. water **B.** mineral salt **C.** glucose
D. fatty acid **E.** amino acid

11. (1.10) The atom can be seen by means of

A. an electron microscope
B. a compound microscope **C.** a geiger counter
D. no instrument now available **E.** a spectroscope

12. (1.10) The molecules that make up substances are

A. in continuous motion **B.** not visible by any means
C. always made up of atoms of different elements
D. colorless **E.** the same in size and shape

13. (1.10) Which of the following groups of elements make up almost 99 per cent of the protoplasm of organisms?

A. Hydrogen and oxygen
B. Carbon, hydrogen, oxygen, and nitrogen
C. Carbon, hydrogen, and oxygen
D. Carbon, hydrogen, oxygen, sodium, and phosphorus

14. (1.10) The most abundant compound in protoplasm is

A. protein **B.** carbohydrates **C.** fat
D. sugar **E.** water

15. (1.10) The elements always contained in proteins are

A. carbon, hydrogen, and oxygen
B. carbon, oxygen, sulfur, and phosphorus
C. carbon, hydrogen, oxygen, and nitrogen
D. hydrogen, and oxygen
E. calcium, sulfur, potassium, and iron

16. (1.10) Protoplasm is a colloidal mixture in which the disperse phase consists largely of

A. water, fats, and proteins
B. organic proteins, fats, and carbohydrates
C. mineral salts, water, and fats
D. ions and water **E.** none of the above

17. (1.10) Of the following choices of food, the one which has the greatest number of different kinds of elements is

A. fats **B.** proteins **C.** starches
D. sugars **E.** minerals

18. (1.10) Simple sugars, double sugars, starches, and cellulose belong to a group of organic compounds known as

A. fats **B.** proteins **C.** carbohydrates
D. enzymes **E.** amino acids

19. (1.10) The substance which in protoplasm acts as the solvent for mineral salts and many organic compounds, that favors movement of materials, and that changes the temperature slowly is

A. protein **B.** water **C.** carbohydrate
D. fat **E.** enzyme

20. (1.10) A chemical system consisting of particles whose size is generally larger than molecules, suspended in a medium of a different substance is a (an)

A. element **B.** compound **C.** water
D. solution **E.** colloid

21. (1.10) Proteins are organic compounds in protoplasm which

A. are composed principally of carbon, hydrogen, sulfur and are stored sources of energy

B. are used primarily for the release of energy
C. are built into the living framework of the protoplasm
D. are important solvents for mineral salts
E. serve as a medium for transporting substances

22. (1.10) A mixture of sugar and water is an example of (an)

A. element **B.** colloid **C.** solution
D. compound **E.** enzyme

23. (1.10) Salts of protoplasm are

A. inorganic and have a regulatory function
B. inorganic and have no function
C. inorganic and a source of energy
D. organic and unnecessary to protoplasm
E. organic and a regulatory function

24. (1.10) The organic constituents of protoplasm are:

A. carbohydrates, salts, and fats
B. carbohydrates, water, and fats
C. carbohydrates, fats, and proteins
D. fats, proteins, and salts
E. fats, proteins, and water

25. (1.10) Which is the most abundant gas in the earth's atmosphere?

A. Oxygen **B.** Water vapor **C.** Hydrogen
D. Nitrogen **E.** Carbon dioxide

26. (1.10) Which kind(s) of decomposition, if any, occur(s) only in the presence of free oxygen?

A. Fermentation **B.** Putrefaction **C.** Decay
D. All of the above **E.** None of the above

27. (1.10) Irridation of milk accomplishes which of the following?

A. Vitamin D is added.
B. Fat globules are reduced in size, making the milk more easily digestible.
C. Vitamin A is added. **D.** Vitamin K is added.
E. None of the above; irridation is just a fad and has no physiological value.

28. (1.10) An element *not* characteristically found in protein is

A. carbon **B.** hydrogen **C.** copper
D. oxygen **E.** iron

29. (1.10) In 100 cubic centimeters of outdoor air there would normally be about how many cu. cm. of carbon dioxide?

A. 30. **B.** 3. **C.** 0.3 **D.** 0.03 **E.** 0.0003

30. (1.10) The average carbon dioxide concentration in outdoor air is about

A. 4% **B.** 21% **C.** 79% **D.** 0.1% **E.** 0.03%

31. (1.10) Which of the following statements best characterizes fats?

A. They are synthesized from amino acids.
B. They contain hydrogen and oxygen in the same proportion as these elements occur in water.
C. They are made up of more complex molecules than are proteins.
D. They serve primarily as protoplasm-building material.
E. They have less oxygen in proportion to hydrogen than do the carbohydrates.

32. (1.10) Proteins are synthesized in plants by the chemical combination of

A. glycerols and carbohydrates
B. carbon, hydrogen, and oxygen
C. carbohydrates, nitrogen, sulfur, and phosphorus
D. fatty acids and carbohydrates
E. carbon dioxide and water

33. (1.10) Large complex molecules are subdivided chemically into smaller, simpler components in digestion by the process known as

A. synthesis **B.** condensation **C.** hydrolysis
D. symbiosis **E.** plasmolysis

34. (1.10) An enzyme is

A. a catalyst **B.** a digestive juice **C.** a hormone
D. an acid **E.** a complex protein

35. (1.10) The inorganic salts which constitute a portion of the human body's internal environment

A. give to the tissue fluids a composition very similar to that of sea water
B. fluctuate in concentration over a very wide range
C. serve no useful metabolic function
D. exert a passive role in the functioning of the body
E. occur in a concentration near the saturation point

36. (1.10) Life (in man) is possible only within a very narrow range just to the alkaline side of neutrality. The relative constancy of this aspect of the internal environment is maintained primarily by

A. inclusion of an adequate amount of citrus or other kinds of fruit in the diet
B. the absorption of lactic acid from the cells of the muscles after contraction
C. the carbohydrate foods eaten
D. the secretions of the endocrine glands
E. the neutralizing or buffering of carbonic acid in the blood by reduced hemoglobin

37. (1.10) We say that water is essential to all life because:

A. it freezes at 0°C
B. it makes up 49%-70% of all protoplasm
C. it boils at 212°F
D. it can be found as a gas, a liquid, or a solid
E. it occurs everywhere in nature

38. (1.10) The number of different *compounds* now known to exist is

A. greater than **B.** less than **C.** the same as

the number of *elements* now known to exist.

39. (1.10) The number of calories of energy *released* when one gram of glucose is oxidized in cellular respiration is

A. greater than **B.** less than **C.** the same as

the number of calories of energy *stored* when one gram of glucose is manufactured in photosynthesis.

40. (1.10) The degree of complexity of a *glucose* molecule is

A. greater than **B.** less than **C.** the same as
the degree of complexity of a *protein* molecule.

41. (1.10) The molecules which make up the chemical compounds in our bones

A. are in motion only while we are alive
B. are not in motion because they are part of a solid substance
C. are in motion so long as the bone possesses a temperature higher than absolute zero

42. (1.10) Brownian movement is

A. the spontaneous movement of tiny dye particles suspended in water
B. the movement of molecules of water which are visible under the microscope
C. the movement of dye particles caused by their bombardment by molecules of water

43. (1.10) A molecule is

A. an indivisible particle of matter
B. the smallest possible particle of a chemical compound
C. the smallest kind of thing which can be seen under high power of a microscope

44. (1.10) Digestion of starch results in the formation of

A. glucose **B.** amino acids **C.** peptones
D. fatty acids **E.** glycogen

45. (1.10) About 80% of the earth's atmosphere consists of

A. oxygen **B.** nitrogen **C.** water vapor
D. hydrogen **E.** carbon dioxide

46. (1.10) Which class of foods yields the greatest number of calories per unit volume?

A. Proteins **B.** Fats **C.** Carbohydrates
D. Mineral salts **E.** Vitamins

47. (1.10) Carbohydrates, fats, and proteins always contain

A. carbon, hydrogen, and oxygen
B. carbon and hydrogen, but not necessarily oxygen
C. carbon and oxygen, but not necessarily hydrogen
D. hydrogen and oxygen, but not necessarily carbon
E. nitrogen

48. (1.10) One of the vitamins aids in the prevention of night blindness. That vitamin is found in

A. yeast **B.** butter **C.** chicken
D. oranges **E.** none of the above

49. (1.10) Which of the following statements best characterizes fats?

A. They are synthesized from amino acids.
B. They contain hydrogen and oxygen in the same proportion as these elements occur in water.
C. They are made up of more complex molecules than are proteins.
D. They serve primarily as protoplasm-building material.
E. They have less oxygen in proportion to hydrogen than do the carbohydrates.

50. (1.10) The hardest substance in the human body is

A. enamel **B.** cartilage **C.** dentine
D. bone **E.** adipose tissue

51. (1.10) Cellulose is a

A. component of chlorophyll
B. material found in cell walls in plants
C. substance found only in trees
D. type of enzyme **E.** plant hormone

52. (1.10) From the standpoint of general biology which of the following statements constitutes the most acceptable description of protoplasm?

A. It is a thick, sticky, semi-fluid, translucent, proteinaceous dynamic system of substances capable of self-perpetuation.
B. It is a carbohydrate material formed by the condensation of large numbers of monosaccharide molecules.
C. It consists of differentiated material within a cell, made up largely of deeply staining chromatin that controls metabolic activities.
D. It is that part of a cell which lies outside of the nucleus and within the cell membrane.
E. It is a substance which produces dissolution of cells by destroying the cell walls and causing a dispersion of the cell contents.

53. (1.10) Which of the following best describes carbohydrates?

A. They are synthesized by green plants from water and nitrogen.
B. They include mono–, di–, and polysaccharides.
C. They are all manufactured directly by the process of photosynthesis.
D. They yield the greatest amount of energy per unit volume of all the known classes of food.
E. They are more complex chemically than proteins.

54. (1.10) Which of the following statements best describes an organic substance?

A. It is a material which is less combustible than an inorganic substance.
B. It is a material capable of being produced only by a living organism.
C. It is a carbon compound and can be synthesized either in the body of a living organism or in a chemical laboratory.
D. It is a compound which always contains nitrogen, sulfur and phosphorus.
E. It is the bridge between living and non-living matter.

55. (1.10) Diffusion gradient means

A. the swelling of dry seeds when they are placed in water
B. the intermingling of molecules or particles of different substances when they are mixed together in a liquid medium.
C. the variation in relative concentration of molecules of a solid or gas in different parts of the solvent immediately after the solute has been introduced.
D. the drawing away of the protoplast from the cell wall, and its contraction toward the center of the cell.
E. the distension of a cell wall accompanying intake of water.

56. (1.10) Any substance which tends to minimize the fluctuations in the hydrogen ion concentration within a cell is called a(n)

A. acid **B.** salt **C.** buffer **D.** amino acid
E. catalyst

57. (1.10) The product of the digestion of food which has both acidic and basic properties is

A. glucose **B.** fatty acids **C.** glycerol
D. amino acids **E.** bile salts

58. (1.10) An element which accounts for little, if any, of the weight of a living organism is

A. oxygen **B.** carbon **C.** helium
D. nitrogen **E.** hydrogen

59. (1.10) The units of structure of proteins are

A. glycerine **B.** amino acids
C. monosaccharides **D.** fatty acids

60. (1.10) The units of structure of fats are

A. glycerine and fatty acids **B.** amino acids
C. monosaccharides **D.** none of the above

Items 61 - 70. Choose your answers from the key.

KEY

A. disaccharid **B.** monosaccharid
C. polysaccharid **D.** other carbohydrate

To which of the above do the following belong?

61. (1.10) Cellulose
62. (1.10) Dextrin
63. (1.10) Dextrose
64. (1.10) Galactose
65. (1.10) Glycogen
66. (1.10) Lactose
67. (1.10) Levulose
68. (1.10) Maltose
69. (1.10) Starch
70. (1.10) Sucrose

Use the following key in answering questions No. 71 through No. 74:

KEY

A. an element **B.** a heterogeneous mixture
C. a homogeneous mixture **D.** a compound
E. none of these

71. (1.10) Simple substances which can be neither decomposed nor transferred into one or another by ordinary means.

72. (1.20) A rock in which the various compounds are easily distinguishable by differences in color and/or by crystalline form or both.

73. (1.20) Oil and water shaken vigorously together

74. (1.20) A solution of sugar in water

75. (1.20) Which one of the following terms includes the other four?

A. Molecule **B.** Atom **C.** Element
D. Compound **E.** Matter

76. (1.20) The most valuable effect of Friedrich Wohler's laboratory synthesis of urea was probably that of

A. making available to agriculture nitrogenous fertilizers
B. clarifying the action of the nitrogen-fixing bacteria
C. removing the barrier between organic and inorganic matter
D. clarifying the sequence of protein digestion and excretion of nitrogenous wastes
E. enabling the development of a convenient diagnosis for sugar diabetes

77. (1.20) Which of the following alterations of a substance would indicate that this substance had undergone a chemical rather than a physical change?

A. Change in density **B.** Change in odor or taste
C. Change in volume **D.** Change in viscosity
E. All of these indicate that the change was chemical.

78. (1.20) For which one of the following reasons may we consider the dissolving of salt in water to be a physical change?

A. The salt becomes invisible.
B. The water combines with the salt.
C. The residue from evaporation of the solution is unaltered.
D. The residue from evaporation of the solution is not salt.
E. None of the above; this is actually a chemical change, and the above are not applicable.

79. (1.20) Consider the following changes: (a) the grinding of wheat to flour; (b) the drying of clothes; (c) the drying of paint; (d) the making of "burnt" toast; (e) the melting of ice. How many of these are strictly physical changes?

A. 1 **B.** 2 **C.** 3 **D.** 4 **E.** 5

80. (1.20) Of the following, the only constituent of soil that cannot arise from the disintegration of rocks is

A. nitrogen **B.** calcium **C.** sulfur
D. organic matter **E.** phosphorus

81. (1.20) The organic groups that in protoplasm act mainly as sources of stored energy and contribute significantly to the plasma membrane are:

A. fats **B.** proteins **C.** carbohydrates
D. enzymes **E.** amino acids

82. (1.20) Select the one example which is not a true solution.

A. Table salt and water
B. Hydrochloric acid and water
C. Alkali (lye) and water
D. Sugar and water **E.** Starch and water

83. (1.20) Of the following, the best concept of the physical nature of protoplasm is that of

A. a jelly-like substance in which are dissolved proteins, fats, and carbohydrates
B. mixtures of several solutions containing salts, proteins, fats, and carbohydrates
C. a complex colloidal system of salts, fats, carbohydrates, enzymes, proteins, and water
D. a watery substance containing small amounts of enzymes, fats, carbohydrates, and salts

84. (1.20) Four of the following are complex carbohydrates. Which one is a *simple* carbohydrate?

A. Starch **B.** Glucose **C.** Cellulose
D. Glycogen **E.** Granulated sugar

85. (1.20) Obtaining a conception of the true nature of protoplasm is made difficult by the fact that protoplasm is

A. electrically charged **B.** made up largely of water
C. a delicately adjusted, ever-changing system
D. composed of chemical compounds
E. a glutinous, viscid substance

86. (1.20) Which one of the following is a logical consequence of the colloidal condition of protoplasm?

- **A.** The characteristics of protoplasm can more readily be determined than would be the case if its constituent particles were very small and obscure.
- **B.** The cell is rendered more efficient as a result of the decreased amount of internal surface area exposed.
- **C.** The cells are capable of taking up less water than they could if the protoplasmic particles were of a larger size.
- **D.** The amount of surface area within each cell is increased considerably.
- **E.** Protoplasm is electrically neutral.

87. (1.20) Which one of the following terms includes all the others?

A. Glucose **B.** Cane Sugar **C.** Cellulose
D. Monosaccharide **E.** Carbohydrate

88. (1.20) Which one of the following is unrelated to the other four?

A. Monosaccharides **B.** Sucrose **C.** Starch
D. Amino acids **E.** Cellulose

89. (1.20) A good indication of the presence of starch in an unknown food sample is the occurrence of a color change upon addition of

A. Winkler's reagent **B.** Benedict's solution
C. phenol red **D.** iodine solution

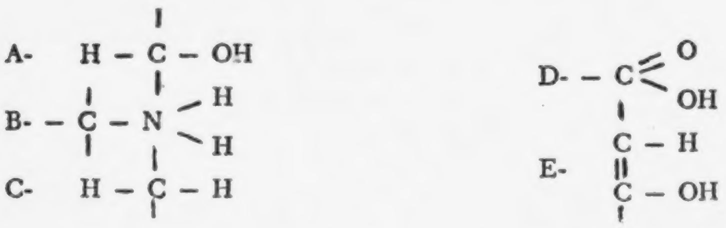
90. (1.20) Of the following ingredients contained in a certain kind of sleep-preventing tablets, which one is probably the active nerve-stimulator that forestalls sleep?

A. Terra alba (white clay) **B.** Aromatic
C. Saccharine **D.** Caffeine alkaloid **E.** Lactose

91. (1.20) Apples darken when peeled. Heat is produced in using a bunsen burner. Water supplies are frequently chlorinated. These events have one common characteristic in that they are

A. physical changes **B.** neutralizations
C. ionizations **D.** oxidations **E.** none of the above

92. (1.20) The grouping of atoms which confers acid properties to both fatty acids and amino acids is



93. (1.20) A peptide link in a protein represents a union between the following two groupings, with loss of one water molecule:

A. A and B of 92 **B.** C and E of 92
C. B and D of 92 **D.** A and E of 92
E. A and D of 92

94. (1.20) A factor which would not influence the rate at which a given substance diffuses into a cell is

- **A.** size of the molecules of the substance
- **B.** concentration of the substance immediately outside the cell
- **C.** rate at which the substance is altered inside the cell
- **D.** chemical properties of the substance
- **E.** none of the foregoing, since all would influence the rate of diffusion

95. (1.20) The physical state of protoplasm is best described as

A. a mixture of emulsified proteins
B. a group of complex polysaccharides
C. metabolic irritability **D.** a colloid
E. a readily diffusable mixture of fats, carbohydrates, and proteins

96. (1.20) Many physical properties of protoplasm can be explained by considering it to be a (an)

A. solution **B.** emulsion **C.** colloidal suspension
D. precipitate **E.** none of the above

97. (1.20) The amount of oxygen present in carbohydrates is

A. greater than **B.** less than **C.** same as
the amount of oxygen present in fats.

98. (1.20) Which of the following elements is found in proteins but not in fats or carbohydrates?

A. Carbon **B.** Hydrogen **C.** Nitrogen
D. Oxygen

99. (1.20) The amount of inorganic matter in bone is

A. greater than **B.** less than **C.** same as
the amount of organic matter in bone.

100. (1.30) In the equation $6CO_2 + 6H_2O + \text{energy} \rightarrow C_6H_{12}O_6 + 6O_2\uparrow$ the weight of the glucose and oxygen resulting from the reaction is equal to the weight of the carbon dioxide and water entering the reaction. This fact is consistent with

- **A.** the Law of Definite Proportions
- **B.** the Law of Multiple Proportions
- **C.** the Law of Conservation of Mass
- **D.** the Law of Conservation of Energy
- **E.** none of the above

101. (2.10) Atom is to oxygen as molecule is to

A. nitrogen **B.** hydrogen **C.** compound
D. element **E.** water

102. (2.10) Atom is to element as molecule is to

A. matter **B.** element **C.** energy
D. compound **E.** water

103. (2.10) When a fat is synthesized,

- **A.** fatty acids combine together
- **B.** simple sugars combine together
- **C.** fatty acids combine with glycerin
- **D.** glycerin combines with a simple sugar
- **E.** amino acids combine to form large molecules

104. (2.10) Molecule is to water as atom is to

A. oxygen **B.** carbon dioxide **C.** fat
D. sugar **E.** amino acid

Items 105 to 110 involve certain chemical processes fundamental to an understanding of biological science. For each item select from the key the appropriate response, then mark the corresponding answer space.

KEY

- A. $6CO_2 + 6H_2O + \text{energy} \rightarrow C_6H_{12}O_6 + 6O_2$
- B. $C_6H_{12}O_6 + C_6H_{12}O_6 \rightarrow C_{12}H_{22}O_{11} + H_2O$
- C. $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + \text{Energy}$
- D. $(C_6H_{10}O_5)_n + nH_2O \rightarrow nC_6H_{12}O_6$
- E. None of the above

105. (2.20) This equation represents cellular respiration.

106. (2.20) This equation represents photosynthesis.

107. (2.20) This equation represents protein synthesis.

108. (2.20) This equation represents digestion.

109. (2.20) This equation represents the transformation of carbohydrate into fat.

110. (2.20) This equation represents the transformation of simple sugar to double sugar.

111. (2.20) The equation $nC_6H_{12}O_6 \rightarrow (C_6H_{10}O_5)_n + H_2O$ represents

- **A.** transformation of a monosaccharide into a polysaccharide
- **B.** decomposition of dead organic matter
- **C.** food manufacturing
- **D.** hydrolysis of a monosaccharide
- **E.** food utilization in the body

112. (2.20) A complete and accurate interpretation of the process whereby glucose is oxidized in the body would be

- A. $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$.
- B. $C_{12}H_{22}O_{11} + 12O_2 \rightarrow 12CO_2 + 11H_2O + \text{Energy}$.
- C. $2NH_3 + CO_2 \rightarrow (H_2N)_2CO + H_2O$.
- D. $C_6H_{12}O_6 + 6O_2 \xrightarrow{\text{Enzymes}} 6CO_2 + 6H_2O$.
- E. None of these.

113. (2.20) Bees are often seen feeding upon rotting apples under the trees in an orchard. Subsequently some of the bees appear to lack coordination when they attempt to fly. This may be explained by

- A. $\overset{\text{(Glucose)}}{C_6H_{12}O_6} \xrightarrow{\text{(yeast)}} \overset{\text{(Ethyl alcohol)}}{2C_2H_5OH} + 2CO_2$
- B. $\overset{\text{(Glucose)}}{C_6H_{12}O_6} + 6O_2 \rightarrow \text{Energy} + 6H_2O + 6CO_2$
- C. $\overset{\text{(Ethyl alcohol)}}{C_2H_5OH} + O_2 \xrightarrow{\text{(bacteria)}} \overset{\text{(acetic acid)}}{CH_3COOH} + H_2O$
- D. $6CO_2 + 6H_2O + \text{Energy} \xrightarrow{\text{(chlorophyll)}} \overset{\text{(Glucose)}}{C_6H_{12}O_6} + 6O_2$
- E. $\overset{\text{(Glucose)}}{nC_6H_{12}O_6} \rightarrow \overset{\text{(Starch)}}{(C_6H_{10}O_5)_n} + nH_2O$

114. (2.20) The phosphorylation of glucose in glycolysis (conversion of glucose to glucose-6-phosphate)

- **A.** yields a compound containing less energy than glucose
- **B.** requires energy supplied by the oxidation of some other molecule
- **C.** produces a compound containing a phosphate bond with as high an energy as in ATP
- **D.** is a type of oxidation reaction
- **E.** is a type of hydrolysis

115. (2.20) The only enzyme in glucose metabolism which catalyzes a reaction using molecular oxygen is

A. catalase **B.** cytochrome oxidase
C. hexokinase **D.** adenosine triphosphatase
E. succinic dehydrogenase

116. (3.00) A glass rod, 1.00 inches long, and 0.25 inches in diameter, is cut with a precision instrument into 100 identical circular discs. These discs are then placed in a crucible and heated for one hour at 100°C. During this entire experiment there will be involved

A. a chemical change **B.** a physical change
C. a chemical and a physical change
D. neither a chemical nor a physical change
E. There are insufficient data from which to draw a correct conclusion.

117. (3.00) An unknown food was tested with the following results: a) Iodine—no change in color; b) Nitric acid—no color change; c) Sudan III—no color change; d) Benedict's solution—color became brick red upon heating. Which one of the following foods would most likely have produced the above results?

A. Lean beef **B.** Irish potato
C. Lemon juice **D.** Butter
E. None of the above would do it; the food must have been something not listed.

118. (3.00) Petroleum, found in certain rock deposits, consists of a variety of compounds composed of carbon and hydrogen. These are all considered to be organic compounds. This is best interpreted as meaning that

- **A.** not all organic compounds result from the metabolism of living organisms
- **B.** petroleum was produced, in geological time, from the remains of living organisms
- **C.** petroleum is one of the components of protoplasm in contemporary organisms
- **D.** petroleum is incapable of being oxidized

5. *Nature of Science and Science Research Methodology*

NATURE OF SCIENCE & SCIENCE RESEARCH METHODOLOGY

1. (1.10) The low power magnification achieved with microscopes used in our laboratories is about

A. 10 – 15 times **B.** 20 – 25 times
C. 40 – 50 times **D.** 80 – 150 times
E. 400 – 500 times

2. (1.10) If an object which is in focus under low power of a microscope remains in focus without further adjustment when the high power objective is swung into position, that microscope is described as being

A. bifocal **B.** parfocal **C.** compound
D. automatic **E.** two-dimensional

3. (1.10) In *Science and Common Sense* the reader is asked to react toward scientific explanations as

A. a dogmatist **B.** a skeptic **C.** the truth
D. reality **E.** laws of nature

4. (1.10) The layman is encouraged by Conant to adopt which of the following views toward scientific explanations that he encounters?

A. Aloofness **B.** Confident acceptance
C. Credulity (belief on slight evidence)
D. Suspended judgment **E.** None of these

5. (1.10) According to Conant the most nearly ideal place for carrying on basic science research is usually in

A. the research laboratory of an industrial plant
B. a drug manufacturing company's research laboratory
C. a university research laboratory
D. a mining company's research laboratory
E. none of the above

6. (1.10) How did scientists regard the invention of the telephone at the time it was invented?

A. It was regarded as highly ingenious.
B. It was considered to be the result of painstaking scientific research.
C. Its inventor, Alexander Graham Bell, received citations from both the American and British Associations for the Advancement of Science.
D. It was quickly hailed as an instrument destined to fulfill a long-felt social need.
E. It was looked upon with disdain as an oddity produced by an eccentric person.

7. (1.10) When scientists are called upon to make decisions involving matters outside of the field of their professional competence, their decisions, according to Conant, are likely to

A. be more conservative than those made by non-scientists
B. be more extravagant and less restrained than those of non-scientists
C. be more exact and impartial than those of non-scientists
D. reflect an unusually high degree of wisdom and good judgment
E. range over the whole gamut of human folly and wisdom much as those of the non-scientists

8. (1.10) "Being well informed about science is not the same thing as understanding science." *Science and Common Sense*, J. B. Conant, Yale U. Press. From the quotation it logically follows that

A. knowing a great deal *about* science is actually a handicap to really *understanding* science.
B. one acquires an understanding of science by learning the laws and principles which are found in the science textbooks.
C. the only way that the layman can hope to understand science is through a greater dissemination of scientific information among non-scientists.
D. understanding science entails something more than learning the facts and principles of science.
E. the author of the statement is apparently an armchair philosopher who had never done scientific work of any significance.

9. (1.10) For which one of the following is it most difficult to obtain government funds?

A. Research to benefit industry.
B. Research associated with preparation for war.
C. Research in the field of medicine.
D. Basic research
E. Research for the benefit of agriculture

10. (1.10) Scientists and laymen frequently have occasion to discuss the work of scientists. Dr. Conant, speaking for scientists, regards as most significant the layman's understanding of the

A. numerous possibilities for technological application of scientific discoveries.
B. scientists' technical knowledge and the technical language used by scientists.
C. scientists' awareness of social forces that create ever-increasing new demands for the products of science.
D. scientists' point of view toward research.
E. efficiency and clock-like precision with which all scientific research is done

11. (1.10) According to Conant, the layman can most effectively acquire an understanding of science by

A. going back in history, to a period when a particular branch of science was in its infancy, and getting an account of the interplay of ideas and method
B. using some of the products of modern science, such as the mechanical refrigerator, radio, and radar
C. making visits to industrial plants, such as those which manufacture automobiles or television equipment, where science is being exploited on every hand
D. going through the laboratories of drug companies or atomic energy plants and observing how scientific findings are being put to practical use
E. watching a skillful surgeon perform a series of intricate operations

12. (1.10) The study of the working or functioning of living organisms is called

A. anatomy **B.** eugenics **C.** pathology
D. ecology **E.** physiology

13. Ornithology is the study of
(1.10)

A. birds **B.** reptiles **C.** mammals
D. insects **E.** fish

KEY (for questions 14-18)

A. histology **B.** pathology **C.** physiology
D. psychiatry **E.** none of these

14. The study of the abnormal mind
(1.10)

15. The study of the microscopic structure of tissues
(1.10)

16. The study of causes of disease and body alterations resulting from disease
(1.10)

17. The study of the care of the body to promote health
(1.10)

18. The science of the structure of organisms as seen by dissection or otherwise with the naked eye.
(1.10)

For each item (19 - 21) select the appropriate word from the key list:

KEY

A. Anatomy **B.** Physiology **C.** Paleontology
D. Genetics **E.** Taxonomy

19. The grouping and naming of organisms
(1.10)

20. The study of the inheritance of organisms
(1.10)

21. The study of the functioning of organisms
(1.10)

22. Which of the following is (are) synonymous with the idea of an hypothesis?
(1.10)

A. Inspired guess **B.** Intuitive hunch
C. Flash of imagination
D. More than one of these **E.** None of these

23. Inductive thinking involves
(1.10)

A. dealing with data in terms of generalizations
B. reasoning from facts to principles
C. discarding a theory if the facts do not agree with it

24. An hypothesis is
(1.10)

A. an explanation of a situation supported by a limited amount of evidence
B. a basic assumption that a scientist uses in his work
C. an explanation which is established as a result of research

25. A scientist believes
(1.10)

A. that the natural forces which made the world as we see it are no longer operating
B. that it is impossible to determine what natural forces made the world as we see it
C. that the world as we see it resulted from the operation of the same forces that we now see operating

26. The law of probability
(1.10)

A. describes the behavior of individual cases
B. describes the behavior of groups of variables
C. always is expressed in the form of a normal or bell curve

27. Scientific laws
(1.10)

A. describe natural phenomena rather than govern them
B. are never disproved after they are once accepted
C. are of the same nature as governmental laws

28. Botany had its origin in
(1.10)

A. describing plants so that early medicine men could identify the ones with the most effective healing powers
B. continuing the arguments first proposed by Aristotle
C. the careful descriptions of plants composed by early herbalists following careful examination resultant from pure curiosity
D. the dissertations composed by monks concerning the mentioning of specific plants in the Bible
E. cataloging the plants that were useful to man as a source of food

Branches of biology (Questions 29-31)

A. Ecology **B.** Embryology **C.** Morphology
D. Physiology **E.** Taxonomy

To which of the above do the following belong?

29. Form and structure of living organisms
(1.10)

30. Relations to surroundings
(1.10)

31. Systematic classification of organisms
(1.10)

32. Horticulture would be classified as
(1.10)

A. pure biology **B.** homoculture **C.** plant physiology
D. applied biology **E.** euthenics

Questions 33 through 37 involve terms used in Science. Select from the key the most closely related terms for each item.

KEY

A. Definition **B.** Observation **C.** Theory
D. Verification of hypothesis **E.** Natural law

33. The atom consists of a positive nucleus with one or more planetary electrons revolving around it in orbital motion.
(1.10)

34. About 1887 Congress passed a law making the yard 3600/3937 of the standard meter.
(1.10)

35. Extensive experiments resulted in the development of the atomic bomb.
(1.20)

36. In every sample of any compound substance, formed or decomposed, the proportion by weight of the constituent elements is always the same.
(1.20)

37. The molecules of an electrolyte are broken up in solution into their constituent radicals, each being charged, and these are called ions.
(1.20)

For items 38 - 49 select the *best* answer.

KEY

A. Perception **B.** Symbolization **C.** Analogy
D. Dichotomy **E.** Empiricism

38. (1.10) Explaining something by comparing it point by point with something else.

39. (1.20) Dr. William Laurence of New York, in a public address, compared the role of the A-bomb in setting off an H-bomb to light fluid or gasoline poured over wet kindling wood in an attempt to get it to burn. This is an example of________.

40. (1.10) A dividing or forking into two subordinate parts.

41. (1.20) In a problem situation it is possible to identify some elements that are known or familiar and some that are unknown or unfamiliar. According to your laboratory manual, until the unknown elements become known by solving the problem we have what is known as________.

42. (1.10) Making something stand for or represent another thing; especially, making a real object represent something abstract or imaginary.

43. (3.00) Automobile is to wagon as motorcycle is to bicycle.

44. (1.10) Experimentation depending upon experience or observation alone and not involving theory or conceptual schemes.

45. (1.10) Awareness of objects or other data through the medium of the senses.

46. (1.20) This person, while she has only an elementary school education, can nevertheless follow directions given in a cook book and prepare an unusually attractive meal. She does not understand the chemistry of cookery but from practical experience achieves noteworthy results. Her method is an example of________.

47. (1.20) Thomas A. Edison is said to have tried more than 600 kinds of materials before deciding upon one to use for making filaments in incandescent electric light bulbs.

48. (1.20) A motorist approaching a railroad crossing, stops quickly when he sees the red blinker lights start flashing. His seeing and interpreting the meaning of flashing lights constitute(s)________.

49. (1.20) By means of lines, arrows, circles, numbers, and a few words, an architect is able to indicate in advance exactly how a building shall be built.

50. (1.20) Which of the following methods of problem solving is (are) embodied in the scientific method?

A. Rationalization
B. Solving the problem on an emotional basis
C. Thinking it through **D.** Two of the foregoing
E. None of the foregoing

51. (1.20) Which of the following represents the lowest degree of certainty?

A. Hypothesis **B.** Principle **C.** Fact
D. Conclusion **E.** Probability

52. (1.20) Which of the following is true of an experiment that is performed without a control?

A. It is often invalid or indecisive.
B. It is usually a fake.
C. It invariably shows carelessness on the part of the experimenter.
D. It is usually quite satisfactory.
E. It should never have been performed.

53. In using scientific method, one should never

A. make guesses **B.** use facts from authority
C. repeat another person's work
D. base his conclusions on anything but experimental data
E. let his own prejudice influence his conclusions

54. (1.20) In order to arrive at the solution to a problem a scientist usually formulates and tests

A. facts **B.** theories **C.** principles
D. laws **E.** hypotheses

Evaluate items 55 to 57 according to the following key.

KEY

A. Behavior typical of the true scientist
B. Behavior typical of one unfamiliar with scientific method
C. Behavior typical of the false scientist or one who is misusing the scientific method with premeditated motives
D. Behavior found equally among true scientists, pseudo-scientists, and those unfamiliar with the scientific method

55. (1.20) Definitely plans his procedure so as to prove the truth but not the falsity of a specific hypothesis.

56. (1.20) Reveals truth with disregard to economic or social consequences.

57. (1.20) Willing to accept as factual, beliefs that have persisted down through the centuries.

58. (1.20) Which of the following means most nearly the same as the word "control" as used in describing a scientific experiment?

A. Preliminary trial experiment
B. Experiment with the variable factor
C. Repeat experiment **D.** Comparison experiment
E. None of the above

59. (1.20) In the laboratory experiments using Japanese color cards and PTC paper, an important property of sense perception was illustrated. This property is suggested by which one of the following statements?

A. Color and taste are properties possessed by objects regardless of who the observer is.
B. The qualities of sense objects perceived by an observer are entirely due to the activity of his nervous system and have no basis in reality.
C. Identical stimuli will arouse identical sense perceptions in all observers.
D. Color and taste result from some interaction between sensory stimuli from an object and the particular nervous system of the observer.
E. The qualities of objects perceived by the observer are sheer illusions and are therefore not reliable.

60. (1.20) If a scientist were asked, "What is Science?", his answer would most likely be:

A. Science is a body of descriptive knowledge which man has accumulated through the centuries.
B. Science is the description of the structure, habits, and habitat of living organisms upon the earth.
C. Science is the process whereby man manufactures all the modern conveniences of living and transportation, and the destructive weapons of modern warfare.

D. Science is the employment of the secret forces of nature in the achievement of man's purposes.
E. Science is the classification and association of facts gained from observational and experimental procedure, discovery of relationships between them and building these up into new ideas.

61. (1.20) Four of the following constitute advantages that may arise from the use of symbolism. Which one is a *disadvantage?*

A. The symbol may become completely dissociated from the object it represents.
B. Under certain conditions the symbol makes unnecessary the manipulation of the object it represents.
C. Information can be stored.
D. Experience can be gained vicariously.
E. A cultural heritage becomes a possibility.

62. (1.20) A symbol, if it is to have value as a means of communication between one person or group and another, must possess which one of the following characteristics?

A. It must suggest to the person using it some characteristic of the object or concept that it represents.
B. It must suggest to the person using it as wide a variety of objects or concepts as possible.
C. It must suggest the same object or concept to all persons using it in the same way.
D. It must have only one meaning regardless of how it is used.
E. It must first have become traditional and accepted by several generations of people.

63. (1.20) A conceptual scheme *differs* from a working hypothesis in which way?

A. There is no indirect evidence to support the conceptual scheme.
B. There is no direct evidence to support the conceptual scheme.
C. Perceived objects are involved in a conceptual scheme.
D. Imagined objects are not involved in a conceptual scheme.
E. There is no actual difference.

64. (1.20) Experimental science began when

A. empirical experimentation converged with deductive reasoning.
B. Aristotle proclaimed that nature abhors a vacuum.
C. Mendel experimented with garden peas.
D. Kepler pronounced his now famous laws of astronomy.
E. the first conceptual scheme was developed through intuitive logic.

65. (1.20) Which of the following is the least desirable attribute a scientist can possess?

A. An objective approach to a problem.
B. Ability to explain results of an experiment by rationalization.
C. Displaying curiosity in regard to the reasons for everyday occurrences.
D. Habit of trying to anticipate what might happen before an experiment is completed.
E. Ability to relate the outcome of a particular experiment to the solution of a complex problem.

66. (1.20) Analysis of a new situation in terms of an old one can perhaps best be done by

A. largely disregarding the old or known and concentrating on the new or unknown
B. formulating hypotheses as to similarities and dissimilarities and testing them
C. first formulating a conclusion, then gathering facts to prove that it is true
D. selecting from the data those facts which prove the point, manipulating these facts to best advantage, and disregarding the rest
E. divesting oneself of any illusions that such a thing is possible

Directions: Items 67 - 70 are based entirely on your understanding of the scientific point of view. For each item, select from the key the best statement and mark the corresponding space on the answer sheet.

According to your understanding of the scientific point of view, mark answer space

A. if the statement is warranted.
B. if the statement is in conflict with the scientific point of view
C. if the statement is neither in agreement nor in conflict with the scientific point of view

67. (1.20) In spite of what he may write, a scientist does not really want criticism of his careful procedures.

68. (1.20) A scientist reads carefully the results of the experiments reported by other scientists so that he can design an experiment that avoids some of their errors.

69. (1.20) A scientist thinks of the laws of nature as decreed by a divine intelligence.

70. (1.20) A scientist assumes that scientific laws are no more than descriptions of relationship in natural processes.

71. (1.20) Which one of the following would be regarded as a conceptual scheme?

A. The study of reproduction in living organisms
B. The gene theory of heredity
C. The cell theory as it relates to living organisms
D. More than one of the above
E. None of the above

72. (1.20) The scientist is skeptical about or has reservations in his mind concerning

A. statements about the past
B. predictions about the future
C. generalizations about what event will follow another
D. more than one of the above
E. none of the above

Items 73 - 76 are statements which are to be categorized according to the following key.

KEY

A. A fact by observation of naturally occurring phenomena
B. A fact demonstrable by the use of experimental procedures
C. A fact by common acceptance
D. More than one of the above
E. None of the above

73. (1.20) A foot is a unit of measurement thought to be equal to the average human foot in length.

74. (1.20) A lift pump, if operated at sea level, will raise water up to a height of about 34 feet, and no higher.

75. (1.20) Matter is composed of atoms

76. (1.20) Red oxide of mercury yields mercury and oxygen when heated.

Items 77 - 82 are concerned with various stages in the social utilization of science in modern life. For each item select the appropriate category from the key, then mark the corresponding answer space.

KEY

A. Fundamental research. **B.** Applied research.
C. Engineering development
D. Production engineering **E.** Service engineering

77. (1.20) This step involves construction and operation of pilot plants.

78. (1.20) This step is concerned with the development of new concepts.

79. (1.20) Reduction of the degree of empiricism is the chief concern in this step.

80. (1.20) This step is concerned with the check-up and maintenance of the product.

81. (1.20) This step involves the improvement in actual large-scale operating units.

82. (1.20) This step is concerned with the application of existing conceptual schemes to the solution of practical problems.

83. (1.20) Which of the following statements about science and scientists is acceptable?

A. The methods of science were the same 200 years ago as they are today.
B. The scientist who has learned to make exact and impartial analyses of facts in science will invariably make exact and impartial analyses in matters not pertaining to science.
C. An assured major outcome of training in science is good citizenship.
D. Scientists in the time of Galileo enjoyed a higher professional status in society than is true of scientists today.
E. None of the above.

84. (1.20) The applied scientist's most precious fuel, i.e., that which keeps him going in his work is

A. his status in society—the high esteem in which he is held by the general public
B. his personal sense of satisfaction in seeing the practical results of his work
C. the well-night limitless supply of equipment and raw materials at his disposal
D. the stiff competition on every hand in rival companies' applied science research laboratories
E. the stream of new ideas and new experimental results coming from the workers in fundamental science research laboratories

85. (1.20) If money is to be granted by foundations, such as Ford, Rockefeller, Carnegie, or Guggenheim, for uncommitted research, which of the following will probably serve best to prevent scientific "boondoggling" or squandering of the money?

A. Competition among individuals and research agencies embarking on similar kinds of research
B. Inspection and close supervision by a representative from the foundation making the grant
C. Requiring the grantee to pledge in advance results that merit publication conforming to an acceptable standard
D. More than one of the above
E. Nothing—in most research a great deal of this occurs; most of the money is squandered unnecessarily

86. (1.20) The chief source of reliable information as to what is going on in the scientific laboratories at the present time is

A. science textbooks **B.** newspapers
C. popular magazines, such as *Reader's Digest*
D. journals of scientific societies
E. radio and television

87. (1.20) Four of the following were examples of uncommitted investigations. Which one was committed?

A. Irving Langmuir, who, when he joined General Electrics' Research Laboratory in 1909, was told to look around and work on anything that interested him.
B. Michael Faraday, director of the Royal Institute (London), which had no fixed program.
C. Charles Darwin who had no definite job during his entire lifetime, but devoted himself to study and writing as inclination led him on.
D. Gregor Mendel, who spent 8 years carrying out, in spare time, one experiment, the significance of which nobody recognized until 35 years after his death.
E. Louis Pasteur, when he was called in for consultation by a French distiller to find a way to increase fermentation efficiency

88. (1.20) Which one of the five statements below would be considered a principle?

A. All living organisms have living enemies which compete with them for available food.
B. The outer germ layer of the embryo is known as the ectoderm.
C. Daughters of the alumnae of an Eastern women's college average 1.1 to 1.5 inches taller than their mothers.
D. A distinguishing characteristic of the duckbilled platypus is the fact that while it is classified as a mammal, it nevertheless lays eggs and incubates them externally.
E. A simple laboratory test for oxygen—the Winkler test—involves the use of manganous chloride and potassium hydroxide.

89. (1.20) Which of the following attributes on the part of a scientist would be most likely to invalidate the results of his experimentation?

A. Curiosity **B.** Analysis **C.** Rationalization
D. Objectivity **E.** Theorizing

90. (1.20) Which one of the following reflects Conant's concept of what science is?

A. Any new process or product used in medicine reflects scientific development.
B. When a process is carried out in an orderly systematic fashion it can be regarded as having been done scientifically.
C. Science is a network of ideas and conceptual schemes developed through experimentation and observation and fruitful of further experimentation and observation.

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D. Science is a way of explaining the structure and operation of the universe in which we live in terms of principles, laws, and theories.
E. Science is nothing more or less than common sense.

91. (1.20) The aspect(s) of industrial research method(s) which is (are) incompatible with basic science research method is (are)

A. the lack of sound training on the part of the typical industrial research worker
B. the desire to obtain solutions to baffling problems instead of getting practical results
C. the use of elaborate and expensive equipment in carrying out experimental work
D. the atmposhere of secrecy in which much industrial research is carried out
E. More than one of the above

92. (1.20) Which of these would Dr. Conant consider to be a fact?

A. A gene is a minute particle located on a chromosome.
B. At sea level water can be raised not more than 34 feet with a lift pump.
C. Matter is composed of atoms.
D. More than one of the above.
E. None of the above.

93. (1.20) Which of the following is a present tendency that is considered detrimental to continued scientific growth and development?

A. Squandering of unduly large sums of money by dreamers on basic science research projects having no immediately foreseeable value
B. Expansion of basic science research at the expense of applied science research
C. The engulfment of basic science research activity by tested applied science interests
D. Curtailment of applied science research programs in all major industries
E. The flocking of highly trained personnel into basic science rather than applied science research positions

94. (1.20) When a scientist, who is engaged in fundamental research, makes a new finding as an outgrowth of his research he usually writes a detailed report of it which eventually is published in the journal of one of the scientific societies. Anyone, anywhere in the world, can usually buy a copy of this issue of the journal in which his report is published. According to Conant, how should this practice be regarded by our government?

A. It should be illegal to distribute any scientific information except to scientists in our own or in friendly countries.
B. This practice should be encouraged—not restricted.
C. All scientists should be employed by the government.
D. All scientific journals should be placed under strict government control.
E. This question has no answer.

95. (1.20) Science is characterized by all *except* which one of the following?

A. Its essence is the sum total of the potential findings of research workers in the laboratories.
B. It is concerned with conclusions based on reason without regard for any particular individual's loyalties or interests.
C. Rapid and easy communication between research workers in identical or related fields is essential.
D. It is dynamic (everchanging) rather than static (consisting of a fixed set of laws, theories, and principles).
E. Its objective is to serve all of mankind in some beneficial way.

96. (1.20) Whether a scientist's new finding is likely to gain acceptance by the scientific world depends very largely upon

A. how well his finding is substantiated with accurate data
B. the reputation of the discoverer, whether he is a well-known or an obscure scientist
C. how emphatic and persuasive the discoverer is when he presents his finding at a meeting of a scientific society
D. the probable practical value of the finding in the development of some new product or in the improvement of an old one
E. sheer chance and nothing else

97. (1.20) Biological Science is designed to give the student an understanding of basic biological principles so that he may better

A. qualify himself in his field of specialization
B. understand the subject matter areas which relate to public health
C. understand the relationships that exist between higher plants and animals
D. understand his own nature and that of the major groups of living things
E. understand the nature of both the chemical and physical world of which he is a part

Items 98 - 101 are concerned with a comparison of SCIENCE and HISTORY. For each item select the most appropriate key category, then mark the corresponding answer space.

KEY

A. Science **B.** History **C.** Both **D.** Neither

98. (1.20) It (they) involve(s) entirely the recording of facts.

99. (1.20) Judgments about the future are made in terms of the past.

100. (1.20) Its (their) content lends itself well to verification.

101. (1.20) Research is involved.

102. (1.20) The dynamic view of science is expressed in which of the following?

A. Science is systematized information.
B. Science consists of a set of principles, laws, and theories.
C. The dogmatic view of science is the same as the dynamic view of science.
D. Science is a way of explaining the universe.
E. Knowledge acquired by fundamental research is of importance as a basis for further operations.

103. Read the following quotations

A. ". . . take for granted the existence of other personalities . . ."
B. ". . . take for granted the existence of objects in space . . ."
C. ". . . take for granted the existence of objects independent of the observer . . ."

D. ". . . take for granted the existence of uniformity in nature . . ."

These four quotations can best be classified as

A. symbolizations **B.** statements of empiricism
C. perceptions **D.** assumptions **E.** none of these

104. (1.20) The assumption by scientists that science, whatever science may be, is something that belongs to everybody

- **A.** contributes little toward scientific progress.
- **B.** indicates that the conclusions of scientists are infallible.
- **C.** should be a political decision.
- **D.** decreases the effectiveness of scientists.
- **E.** is manifested by publication.

105. (1.20) "How can the intestine, lying some distance away, cause the pancreas to release its digestive enzymes at just the right moment?" The foregoing quotation would be considered a

A. tentative hypothesis. **B.** fact by definition
C. problem. **D.** principle. **E.** demonstrable fact.

106. (1.20) Medical research scientists are constantly under criticism by antivivisectionist groups for using dogs in experiments to test the effectiveness of newly-developed drugs in combatting certain diseases of mankind. What is the *most compelling* reason why snakes are not used instead of dogs?

- **A.** Medical research scientists feel that snakes have greater biological conservation value than dogs—hence they choose to sacrifice the less valuable animals.
- **B.** Snakes would be more difficult to house in the laboratory than dogs.
- **C.** Snakes reproduce too slowly to be satisfactory.
- **D.** Infectious bacteria which find optimum temperature conditions in man's body are not likely to multiply in snakes.
- **E.** No research worker likes to handle snakes—they are too repulsive and too dangerous.

107. (1.20) How does a science that has "come of age" tend to differ from that same science when it was in its early stages of development?

- **A.** In a maturing science the subjects covered are dealt with primarily in a descriptive manner.
- **B.** A young science is characterized by a greater sensitivity to problems.
- **C.** A maturing science is characterized primarily by a high regard for authoritarian pronouncements which have come down from the past.
- **D.** The characteristics of a maturing science are theories, principles, and laws based on interrelationships of facts.
- **E.** There are no differences—a young science and a maturing science are essentially the same in every respect.

108. (1.20) All *except* which *one* of the following can be regarded as objectives of general education?

- **A.** To provide an opportunity for specialized training.
- **B.** To explore broad areas of knowledge.
- **C.** To assist students in a discovery of latent interests and aptitudes.
- **D.** To provide a larger understanding and appreciation of the relationship of one's major specialty to the needs of society as a whole.
- **E.** To equip students better to assume their responsibilities as individuals and as citizens of a democracy.

109. (1.20) Which of the following constitutes the *most adequate* statement as to what is *meant* by science?

- **A.** Science is a body of descriptive knowledge which man has accumulated through the centuries.
- **B.** Science is the description of the structure, habits, and habitat of living organisms upon the earth.
- **C.** Science is the process whereby man manufactures all the modern conveniences of living and transportation, and the destructive weapons of modern warfare.
- **D.** Science is the employment of the secret forces of nature in the achievement of man's purposes.
- **E.** Science is the classification and association of facts gained from observational and experimental procedure, discovery of relationships between them, and building these up into new ideas.

110. (1.20) Which of the following means most nearly the same as the word "control" as used in describing a scientific experiment?

A. Preliminary trial experiment.
B. Experiment with the variable factor.
C. Repeat experiment. **D.** Comparison experiment.
E. None of the above.

111. (1.20) What purpose does a control serve in an experiment?

- **A.** The control insures against error in performing the experiment.
- **B.** Every scientific experiment of any consequence that has ever been performed has had a control.
- **C.** Interpretation of the fact arising from the experimental phase is made more valid when there is a standard for comparison.
- **D.** The control makes it possible to test many variables at one time.
- **E.** The control doesn't actually serve any real purpose, but it is used to impress non-scientists with the dignity of scientific work.

112. (1.20) What characteristic must any material have if it is going to be possible to see its underside through a microscope?

A. It must be opaque.
B. It must be light colored.
C. It must be stained. **D.** It must transmit light.
E. None of the above is necessary—the material viewed appears to be turned over so the underside is the first side one sees.

113. (1.20) Except as regards the industrial application of science, scientific information discovered through research should, under the most ideal conditions, be

- **A.** kept highly restricted within the country in which it was discovered or developed.
- **B.** patented immediately, then released.
- **C.** freely disseminated through the medium of publication.
- **D.** channeled through a board established by the government of the country in which the discovery was made or developed.
- **E.** passed upon by a congressional committee before being released.

114. (1.20) Four of the following are acceptable procedures to follow or interpretations to be made when using a compound microscope. Which one is *not* acceptable?

A. Always carry the microscope horizontally.
B. When using high power, focus with the fine adjustment only.
C. If the microscope is parfocal the object that was in focus under low power should require little if any additional focusing when the high power objective is swung into position.
D. Focusing should begin by raising the objective from a position in which it clears the slide about one-fourth of an inch.
E. The orientation of the field of view can be expected to be reversed but upright.

115. (1.20) The environment in which a present-day scientist works exerts many pressures on him which tend to foster impartiality and objectivity in his work. Which one of the following, on the other hand, would tend to *decrease* objectivity?

A. Vested interests of a manufacturer who employs him.
B. His own high degree of specialization in his field.
C. The tradition for unbiased reporting in scientific circles.
D. The precision made possible by present-day instruments.
E. His fellow scientists who read his report in a scientific journal.

116. (1.20) Which of the following represents the lowest degree of certainty?

A. Hypothesis. **B.** Principle. **C.** Fact (or Observation).
D. Conclusion. **E.** Probability.

117. (1.20) The degree of empiricism characteristic of the work of a surveyor is at or near zero because

A. his work is strictly routine after he has learned how to do it.
B. he solves his problems largely by the use of symbols instead of using cut-and-try or trial-and-error methods.
C. he must adapt his methods to conditions as he finds them in the field.
D. the salary earned by a surveyor is usually rather modest.
E. surveying is a type of work which requires highly specialized training.

Items 118 - 124 consist of statements that describe the activities of artisans, scientists, both, or neither. For each item select from the key the most appropriate category.

KEY

A. Artisans **B.** Scientists **C.** Both **D.** Neither

118. (1.20) Their procedure nearly always is almost wholly empirical.

119. (1.20) They are concerned with general ideas and logical thought, with no immediate utilitarian goal in mind.

120. (1.20) Their aim is to attain a practical objective.

121. (1.20) They perform experiments.

122. (1.20) They work mainly with conceptual schemes.

123. (1.20) The chef in a first-rate hotel would belong in this category.

124. (1.20) They are primarily concerned with supernatural pursuits.

Items 125 - 132 consist of statements which either embody one or more views of science or are not concerned with science at all. For each item select from the key the category which best applies, then mark the corresponding answer space.

KEY

A. Static View of Science
B. Dynamic View of Science
C. Both **D.** Neither

125. (1.20) Science is concerned with an interlacing set of principles, laws, and theories plus a vast array of systematized information.

126. (1.20) Science is chiefly concerned with mental telepathy and extrasensory communication.

127. (1.20) Science is essentially an activity in which the present state of knowledge is of importance, not in itself, but chiefly as a basis for further operations.

128. (1.20) Science consists of an accumulated body of knowledge set forth in textbooks which explain how the universe is constructed and how it works.

129. (1.20) Science is a speculative enterprise which involves an interconnected series of concepts and conceptual schemes which have resulted from experimentation and observation and which serve as the basis for further experimentation and observation.

130. (1.20) Science is not a quest for certainty; it is rather a quest which is successful only to the degree that it is continuous.

131. (1.20) When the terminal point (goal) has been reached, when the puzzle has been solved, and the structure of the universe discovered, the laboratories can be closed and mankind can take up other tasks.

132. (1.20) Science is primarily concerned with logic, ethics, aesthetics, metaphysics, and the theory of knowledge.

133. (1.20) Fundamental research should be supported by

A. the government. **B.** foundations.
C. individuals who are interested and can afford it.
D. industrial companies.
E. more than one of these.

134. (1.20) Which of the following methods of problem solving is (are) embodied in the scientific method?

A. Intuition.
B. Solving the problem on an emotional basis.
C. Thinking it through. **D.** Two of the above.
E. None of the above.

135. (1.20) The chief justification for including Natural Science in a General Education curriculum is

A. the desirability of making research scientists of all people who live in this generation.
B. that it is essential to an understanding of how all our modern gadgets work.
C. its emphasis on logical thinking.
D. that it is primarily concerned with practical applications of science.

E. that it provides an extensive and intensive survey of all the sciences.

136. Why is scientific method emphasized to the degree that
(1.20) it is in General Education Science courses?

A. General Education Science courses have been designed primarily for future scientists.
B. Every item of scientific knowledge that has ever been recorded has been discovered or developed by employing the scientific method.
C. Scientific method is unique to General Education Science courses.
D. The scientific method represents a way of thinking that could be extremely useful in the solution of everyday problems.
E. Educators have long ago discovered that method is more important than content.

137. The primary function of General Education is to teach
(1.20) people how to

A. live together in the modern world.
B. become outstanding leaders in the professions, government, business, and industry.
C. become distinguished scholars.
D. become outstanding scientists.
E. earn a living through the use of technical skill it has provided.

138. The degree of certainty of an *hypothesis* is
(1.20)

A. greater than **B.** less than **C.** the same as
the degree of certainty of a *principle.*

139. Which one of the five statements below would be con-
(1.20) sidered a principle?

A. The outer germ layer of the embryo is known as the ectoderm.
B. Daughters of the alumnae of an Eastern women's college average 1.1 to 1.5 inches taller than their mothers.
C. A distinguishing characteristic of the duckbilled platypus is the fact that, while it is classified as a mammal, it nevertheless lays eggs and incubates them externally.
D. All living organisms have living enemies which compete with them for available food.
E. A simple laboratory test for oxygen—the Winkler test—involves the use of manganous chloride and potassium hydroxide.

140. As a first step after defining his problem, a scientist
(1.20) usually

A. starts with some physical law
B. uses some established theory
C. relies solely upon the inductive method.
D. reaches a conclusion from the facts and tests it.
E. sets up an hypothesis and tests it.

141. The scientific method
(1.20)

A. is of little practical use in biology because of the difficulty of conducting experiments on humans.
B. must rest on the assumption that there is an orderliness in nature.
C. need not involve the accumulation of facts or the use of hypotheses.
D. may be useful even when the objective viewpoint is disregarded.
E. always results in the precise explanation of the observable phenomena.

142. An hypothesis is a statement which
(1.20)

A. postulates a generalization which goes beyond the facts already known.
B. provides a summary of proven fact and is so highly probable that it becomes one of the "laws" of science.
C. is the final authority of scientific research.
D. must never be discarded as untenable.
E. is usually accepted without objection by most scientists.

143. Which of the following is a fundamental principle of
(1.30) scientific thinking?

A. The simplest explanation, interpretation, or solution to a problem is the most acceptable.
B. Whenever there is a choice between a scientific term and a simple English word that has the same meaning the scientific term is invariably to be preferred.
C. If scientist A uses three steps in solving a problem and scientist B uses five steps, it will be assumed that the solution worked out by scientist B is inevitably the better one.
D. If scientist A performs an experiment having one variable and scientist B performs the same experiment in such a manner that three variables are operating simultaneously it will be assumed that scientist B will obtain more decisive results.
E. In the field of science man's knowledge is increased only through the use of controlled experiments.

144. An hypothesis at the time it is formulated is most like
(2.10) which one of the following?

A. A "shot in the dark." **B.** A shrewd guess.
C. A theory. **D.** A problem. **E.** A fact.

145. If $\pi = c/d$, then which one of the following relation-
(2.10) ships does not follow?

A. $\pi \times d = c$. **B.** $c/\pi = d$.
C. $(\pi \times d)/c = 1$ **D.** $c - (\pi \times d) = 0$
E. $\pi \times c = d$

146. The statement "This is the Age of Science" means
(2.10)

A. that the majority of the general population of the civilized countries of the world thinks scientifically in their everyday life activities.
B. that, quite generally, those who are in positions of leadership (government, law, education, religion) think scientifically or critically and seek to lead others on the basis of such thinking.
C. that each succeeding generation in the present century tends to have a higher average intelligence than the preceding one.
D. that every day, with scarcely a thought about the method that made them possible, we use the comforts and conveniences developed on the basis of thinking done by a few.
E. none of the above.

147. If you were told that an animal measured one micron
(2.10) you would know that the animal was in length

A. 1/1000 of a millimeter. **B.** 1/1000 of a centimeter.
C. 1/1000 of a meter. **D.** 1000 times [illegible]er.
E. 1000 times a millimeter.

148. A three-dimensional concept of an object being observed
(2.20) with the microscope is realized by

A. actually seeing the width and length and imagining the depth.

B. actually seeing a series of two-dimensional pictures which the mind ties together to give the concept of thickness.
C. actually observing a single field with the high power objective lens.
D. actually observing a single field with the low power objective lens.
E. some method other than those listed above.

149. (2.20) Which of the following best describes the present status of science in the United States of America?

A. The methods of science constitute the way of life and thinking of most Americans.
B. The widespread example of man's inhumanity to man are products of the "Age of Science."
C. The fact that most people about us have at least heard of such things as Rh-factor, blue babies, blood type, and have been exposed in one way or another to the benefits of modern sanitation, immunization, and surgery is evidence that they have a basic understanding of science.
D. The average citizen is most naive in his understanding of science and views the scientist as a miracle man.
E. No appraisal is possible.

150. (2.20) The spirit of science is reflected by

A. those who make discoveries and modestly report nothing.
B. unscrupulous criticism of the work of others.
C. rationalization of findings to fit predetermined hypotheses.
D. uncritical acceptance of the work of others.
E. publication of significant findings in journals which are available to people of all nations.

151. (2.20) Judging on the basis of his writings, it would be most appropriate to characterize Antony van Leeuwenhoek as a

A. philosopher who expounded many hypotheses and theories.
B. refined gentleman.
C. keen observer of living organisms. **D.** charlatan.
E. quasi-scientist, who, while honest, could hardly be rated as a scientist.

Items 152 to 157 refer to the following direct quotation from an article in *The Philosophical Magazine* of April, 1799 written by F. W. A. Murhard.

We are told in the History of the Academy of Sciences of Paris for the year 1719, that a toad was found inclosed in an elm as thick as a man's body . . . Charles Hall, a merchant at Eberach, saw a living toad sitting in a stone, upon its being broken. Martin Weinreich relates a circumstance of the like kind; and John Nardius says that he found in a block of marble a living snake . . .

In the year 1733 a living toad was found by J. M. Graberg in a solid block of stone, dug up from a quarry in the parish of Wamblingebo, in Gothland, and which he caused to be broken by the workmen . . . Having touched it on the head with a stick, it contracted its eyes as if it had been asleep . . . He remarked also that the mouth had no aperture (but) it was covered with a yellowish skin, which he examined also with the stick, but he was not able to make it open it . . .

T. Whiston relates, that in the year 1743 a stone cutter named Charlton found near Wisbich, in the Isle of Ely, a living toad inclosed in a piece of marble. Being called to the spot, he saw the animal, and the cavity in which it was contained. The latter was somewhat larger than the toad, and had almost the same figure. The animal was of a dark yellow colour; and the solid marble, which inclosed it on all sides, was several inches thick. It seemed to be quite healthy, and by its long confinement had not become meagre . . .

M. le Cat, who relates many instances of the like kind, examines the possibility of them, and the causes of such phenomena. Some philosophers have been of the opinion, that the eggs of these animals, created by the Supreme Being at the beginning of the world, and floating about on the watery expanse, have since that time been enclosed in the interior parts of the rocks . . .

At a period like the present, when so many things are made the subject of experiment, when everyone endeavors to tread in the footsteps of a Bacon and a Newton, and, instead of being contented with surveying Nature in her private recesses and carefully watching her progress, compels her as it were to labour and make known her secrets, I am much astonished that she has not been put to the proof in this respect long ago. Such experiments, without which all theory must ever remain mere hypotheses, and can never amount to demonstration, would require little or no expense. Nothing would be necessary but to make a deep hole in a stone; to enclose some animal in it, such for example as a toad, and to prevent the air from penetrating to it; or eggs only might at first be put into the stone. It would, however, be attended with most advantage if several experiments were made at the same time, in order that the state of the animals might be examined at different periods.

152. (2.20) Biological science, developed since Murhard composed these accounts, has proved that these stories as a whole are

A. exaggerations of observations to the point of falsity.
B. pure myths or folk tales. **C.** absolutely untrue.
D. fairly accurate accounts of observed phenomena.
E. none of the above; such stories still appear today and biological science can neither prove nor disprove them.

Using the responses under item 152 as a key list indicate for items 153 to 155 which response is most authenticated by the statements adapted from the syllabus. Use space E if the statement authenticates none of the first four.

153. (2.20) All living things have a common structural pattern.

154. (2.20) Living things assimilate and utilize materials and energy

155. (2.20) Living things are adapted to their environments.

156. (2.20) Careful reading of these accounts reveals that the author

A. did his work before the scientific method was an established practice.
B. had many characteristics of the true scientist.
C. was as much in accord with the mythology and superstitions of his day as his contemporaries.
D. paid total attention to other sources as authority.
E. had no place in his mind for the scientific method as we now understand it.

157. (2.20) The greatest weakness of the experiment suggested by Murhard is

A. inadequate duplication of the problem conditions.
B. the inadequacy of the sample.

C. failure to provide for accurate recorded observations.
D. that it would not answer the question at the core of the problem.
E. that it is planned with the biases and prejudices of the experimenter too apparent.

158. (2.20) Improvements in iron and steel manufacture were made in England by 1790 before the fundamental chemical distinction between cast iron, wrought iron, and steel was recognized. This would tend to indicate that

A. the degree of empiricism in this field was probably very low at that time.
B. basic research in fundamental science had reached a high level by that time.
C. manufacturing processes have for centuries been dependent upon research findings in basic science.
D. the degree of empiricism in this field was probably very high at that time.
E. before a process can be put to practical use it must be thoroughly understood.

Items 159-162 consist of two viewpoints (*a* and *b*). These items are to be appraised in terms of the following key:

KEY

A. Both viewpoints are acceptable as scientific explanations.
B. Only viewpoint *a* is acceptable, because it is logical in terms of cause and effect.
C. Only viewpoint *b* is acceptable, because it is logical in terms of cause and effect.
D. Neither viewpoint is acceptable as a scientific explanation.

159. (2.20) When we stimulate a frog's hind leg, the frog withdraws the leg

a. to get away from the stimulus which is objectionable.
b. because nerve impulses travel from the point of stimulation to the spinal cord over the sensory pathway and back again over a motor pathway, and stimulate the muscles to contract the leg to move.

160. (2.20) Why do the wheels of a passing car turn around?

a. Because gas combustion moves pistons, which move connecting rods, causing the driving shaft to revolve and the wheels to turn.
b. Because there are people in the car who have a plan and goal in mind which involves getting to a destination.

161. (2.20) Why does the upper part of a living green plant turn towards the light?

a. Because all green plants use light, therefore the plant must get light for photosynthesis.
b. Because some physico-chemical relationship causes the plant to turn to the light.

162. (2.20) A student breathing for three minutes into a closed balloon system breathes faster each succeeding minute because

a. oxygen is required by his body and the lack of it makes him breathe faster in order to get more of it.
b. he needs to get rid of the accumulating carbon dioxide.

163. (2.20) The microscope was not basic to the discoveries of which of these scientists?

A. Hooke. **B.** Leeuwenhoek. **C.** Malpighi.
D. Mendel. **E.** Jenssen.

164. (3.00) "I have steadily endeavored to keep my mind free so as to give up any hypothesis however much beloved (and I cannot resist from forming one on every subject) as soon as all available facts are shown to be opposed to it." This statement would tend to indicate that its author was a man who

A. lacked convictions.
B. had little or no insight.
C. exemplified intellectual honesty.
D. might be very dogmatic in his views.
E. would be easily swayed by propaganda.

165. (3.00) When an architect draws a set of plans for a building he employs which of the following?

A. Operational behavior in terms of objective "signs."
B. Direct experience trial-and-error.
C. Immediate perception and reaction to the object.
D. Substitutes for direct experience.
E. None of the above.

166. (3.00) "So I offer this book with the wish that what in it is sound be promptly absorbed into the growth of the science, and the unsound be as promptly forgotten. Indeed, the swiftness of its disintegration will measure the rate of progress of the subject. If it is utterly superannuated in twenty years, that will be well; if, in ten years, it is a back number, that will be better. Perish the book, if only social psychology may go forward! Hence, I beg messieurs, the discreet critics, to lay to right heartily, remembering that in showing its errors they are triumphing *with* the author, not *over* him."—Edward Alsworth Ross, *Social Psychology*, 1908.

The attitude of the above author can be characterized as that of a person who

A. lacks confidence in himself. **B.** is outmoded.
C. is a pseudo-scientist.
D. is a scientist in the true sense of the word.
E. is a skeptic and an agnostic.

167. (3.00) A scientist went into a village whose population was evenly divided between natives of the village and a group of immigrants. He was testing a serum which was supposed to protect against a particular disease so he gave the serum to the natives and nothing to the immigrants and later compared the number of cases of the disease in each group. This procedure could have been improved by which one of the following designs?

A. Inject the natives with the full amount of serum and inject the immigrants with half the amount of serum and compare results.
B. Inject the natives with serum and half the immigrants with serum and compare results.
C. Inject the natives with serum and inject the immigrants with a harmless inactive solution so the psychological reaction is eliminated.
D. Inject half the natives with serum, the other half with a harmless, inactive solution and inject half the immigrants with serum and the other half with a harmless, inactive solution and compare results.
E. Because the experiment involves human subjects there is no way in which the design could be improved.

168. (3.00) "When a person speaks of life he has certain concepts in mind. The power of moving about is associated with life but all living things do not possess this power. Plants are alive and yet many of them do not move about

Crystals grow, hence growth cannot be a characteristic which is restricted to living things. Respiration is considered by some to be the best criterion, but respiration is oxidation or burning, a phenomenon also found in the burning of oil, wood, or coal." The major problem presented in the above paragraph is

A. Do all living things move about?
B. Is growth restricted to living things?
C. Can any except non-living substances be oxidized?
D. Do all people interpret life in the same way?
E. What is life?

Each of the items 169 to 172 presents a brief description of an experiment followed by a conclusion drawn from the experiment. Use the *most* applicable statement of the key to evaluate the conclusion. Observations made during the course are to be considered factual in marking these items.

KEY

A. The conclusion does not answer the problem prompting the experiment.
B. The conclusion is not in agreement with the facts of the experiment.
C. There are not enough facts revealed by the experiment to make the conclusion valid even though the conclusion is in agreement with biological science.
D. Due to the lack of proper controls or other poor experimental technique, the observations from the experiment prompted a conclusion in disagreement with accepted biological science.
E. The conclusion is tentatively justified.

169. (4.20) Two students desired to show that they are of the same blood type. Each drew a small sample of blood, the samples were diluted with physiological salt solution and then mixed. Observation under a microscope showed no clumping of the corpuscles.

Conclusion—The students have the same blood type.

170. (4.20) To prove that the accumulation of carbon dioxide in the lungs affects the rate of breathing, a student breathed into an instrument that eliminated exhaled carbon dioxide and also controlled the oxygen content of the inspired air. These observations were recorded.

		Percentage Composition of Air in Instrument	
Time	Breathing Rate	Oxygen	Carbon Dioxide
0	16	60	.03
5	15	50	.03
10	17	40	.03
15	18	30	.03
20	18	20	.03
25	18	15	.03

Conclusion—An increase in the carbon dioxide concentration of inspired air will increase the breathing rate.

171. (4.20) To answer the question, How do we learn?, a group of students obtained ten pens of identical white rats. They were divided into two groups of five pens and treated identically except that one group was given training in finding food hidden in a maze. This training involved practice in which the rats received an electrical shock each time they made the wrong turn. At the conclusion of the experiment a trained rat could find the hidden food in one minute but it required five minutes for an equally hungry but untrained rat.

Conclusion—We learn by the satisfaction of a successful trial and the dissatisfaction of an unsuccessful error.

172. (4.20) Two students desired to know whether all mosquitos spread malarial fever. They captured many specimens of three kinds of wild mosquitos, types A, B, and C. They examined the digestive tracts of all three types. They found malarial parasites only in type A mosquitos.

Conclusion—Malarial fever is spread by Type A mosquitos but not by types B and C.

173. (5.20) ESSAY (Suggested time: 2 hours)

You are to write an essay on the relation between physics and biology. The materials of the spring quarter have been selected to help you to bring your knowledge of the natural sciences to bear upon this problem.

The Bernard reading represents a view which can be used as a starting point for your analysis; for the later authors, Bohr, Schrödinger and Delbrück, may be said to agree with Bernard, in that none believes in extra-physical "forces" such as Bernard rejects, while all accept the fact of "organization" in living things.

Your essay should therefore include an analysis of the sense in which physics and chemistry "explain" biology according to Bernard. Since Schrödinger, Delbrück and Bohr agree with Bernard in the sense indicated above, it will be part of your task to make clear what further problems exist for them, and what differences there are among the views presented by the four authors. In this connection, the relevance of changes in physics and biology since Bernard should be considered.

Although the spring quarter readings are to serve as the nucleus of your discussion, it is upon the issues represented rather than the particular authors' views that your emphasis should be placed. Therefore, you should be sure to make clear not only the positions of the authors, but the grounds or reasons for these positions, and the nature of the evidence which might suffice to decide the issues.

174. (1.20) The most valuable effect of Friedrich Wohler's laboratory synthesis of urea was probably that of

A. making available to agriculture nitrogenous fertilizers.
B. clarifying the action of the nitrogen-fixing bacteria.
C. removing the barrier between organic and inorganic matter.
D. clarifying the sequence of protein digestion and excretion of nitrogenous wastes.
E. enabling the development of a convenient diagnosis for sugar diabetes

6. *Cell Theory, Cell Structure and Function*

CELL THEORY
CELL STRUCTURE AND FUNCTION

1. (1.10) Of the following the one which is found in the highest percentage in the protoplasm of a typical cell under typical conditions is

A. protein. **B.** carbohydrate. **C.** water.
D. mineral matter. **E.** fat.

2. (1.10) The production of a new useful material by cells is called

A. digestion. **B.** secretion. **C.** induction.
D. agglutination.

3. (1.10) Which of the following forms the boundary of an animal cell?

A. nucleus. **B.** centriole. **C.** mitochondria.
D. plasma membrane.

4. (1.10) The Cell Theory was stated as an hypothesis by

A. Schleiden and Schwann. **B.** Leeuwenhoek.
C. Malpighi. **D.** Hooke. **E.** LaPlace.

5. (1.10) A mass of protoplasm that is a unit of structure, function, and development is called

A. an organ. **B.** a tissue. **C.** a plastid.
D. a virus. **E.** a cell.

6. (1.10) The structure in the cells that controls and regulates cell activities, and functions in transmission of heredity factors is the

A. nucleus. **B.** cytoplasm. **C.** plasma membrane.
D. vacuole. **E.** centrosome.

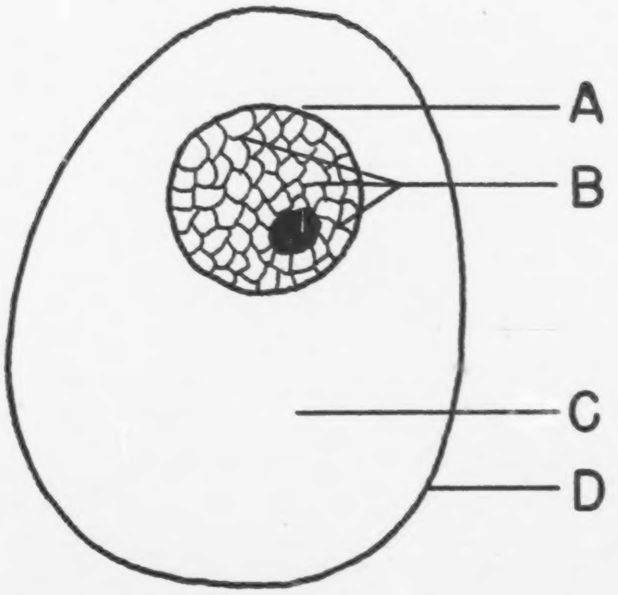
7. (1.10) In plant cells, a pigment important in the manufacture of carbohydrates from carbon dioxide and water is contained in the

A. nucleus. **B.** cytoplasm. **C.** centrosome.
D. vacuole. **E.** chloroplast.

8. (1.10) Cellulose is found in the cell walls of

A. all plants. **B.** higher plants. **C.** all animals.
D. plants and animals.

Items 9 - 13.



DIRECTIONS: Blacken the answer space corresponding to the *one* part of an *animal cell* diagrammed above, to which the statement refers. If the statement refers to *none* of the label parts, *blacken* answer space E.

9. (1.10) This is the cytoplasm.

10. (1.10) This is the cell wall.

11. (1.10) All components of cytoplasm are derived from particles which have passed through this.

12. (1.10) A special mechanism insures that this part of the cell is divided equally between the two daughter cells when the cell divides.

13. (1.10) This part of the cell condenses to form chromosomes during cell division.

14. (1.10) The plant cell wall is chemically composed chiefly of

A. carbohydrates. **B.** steroids.
C. fats and other lipids. **D.** proteins.
E. a complex of lipids and proteins.

15. (1.10) A structural component of cells which can be demonstrated, but not seen with the ordinary microscope, is the

A. nucleus. **B.** chromosomes. **C.** plasma membrane.
D. chloroplast. **E.** nucleolus.

16. (1.10) The membrane on the surface of the cytoplasm is called

A. plasmodesma. **B.** vacuole membrane.
C. middle lamella. **D.** plasma membrane.
E. cytosome.

17. (1.20) If you were looking at some cells through a microscope, they could definitely be identified as plant cells and not animal cells if they had

A. nuclei. **B.** chromosomes. **C.** vacuoles.
D. cell membranes. **E.** cell walls.

18. (1.20) One of the most marked differences between animal cells and plant cells is that

A. plant cells usually have one or more vacuoles.
B. animal cells ordinarily have a nucleolus within the nucleus.
C. animal cells have their nuclear chromatin attached to the linin fibers.
D. nucleoplasm is unique to the animal cell.
E. plant cells usually have relatively thick, rigid walls.

19. (1.20) Which one of the following statements concerning cell division is most nearly correct?

A. In all of the cells of a given species of plant or animal the number of chromosomes which appear at the time of each nuclear division is the same, but the chromosome number differs greatly in different species.
B. In all cells of plants and animals, except certain reproductive cells, the number of chromosomes which appear at the time of each nuclear division is the same.
C. In all cells of a given species of plant or animal, the number of chromosomes which appear at the time of each nuclear division is one-half the number of chromosomes found in the reproductive cells.

- **D.** In all of the cells of a given species of plant or animal, except certain reproductive cells, the number of chromosomes which appears at the time of each nuclear division is the same, but the chromosome number differs greatly in different species.
- **E.** In all the cells of a given species of plant, except certain reproductive cells, and in all the cells of a given species of animal, the number of chromosomes which appears at the time of each nuclear division is the same, but the chromosome number differs greatly in different species.

20. (1.20) If you were looking at some cells through a microscope, they could be identified as animal cells if they contained

A. nuclei. **B.** chromosomes. **C.** vacuoles.
D. chloroplasts. **E.** no cell walls.

21. (1.20) In the following pair, blacken space A if the first element of the pair is definitely greater than the second; space **B** if the second is definitely greater than the first; and space **C** if the two are approximately equal.

A. Nuclei in a single neuron of a human being.
B. Nuclei in a mature red blood cell of a human being.

22. (1.20) Four of the following are generally common to both plant and animal cells. Which one is *not?*

A. Cell wall. **B.** Cell membrane. **C.** Nucleus.
D. Cytoplasm. **E.** Vacuole.

23. (1.20) Of the following characteristics, which one is common to *all* living cells?

- **A.** Cellulose cell wall.
- **B.** Nuclear material scattered throughout the cell.
- **C.** Cell membrane. **D.** Chloroplasts.
- **E.** More than one of the above.

24. (1.20) Which of the following represents the smallest group of substances that includes both the material from which the plant cell wall is made and simple sugar?

A. Organic substance. **B.** Cellulose. **C.** Starch.
D. Double sugar. **E.** Carbohydrate.

25. (1.20) How can you decide most easily whether certain cells being examined under the microscope are plant cells or animal cells?

- **A.** Take the ratio of the longest axis to the shortest axis as measured in microns.
- **B.** Note whether the cells are cuboidal, spherical, tetrahedral, or flattened and tile-like.
- **C.** Note the thickness and character of the cell boundaries.
- **D.** Note whether or not the cells are ciliated.
- **E.** Note whether or not the cells have spores.

26. (1.20) Animal and plant cells are similar in all except which one of the following characteristics?

A. Nucleus. **B.** Cytoplasm. **C.** Nuclear membrane.
D. Cell membrane. **E.** Cell wall.

27. (1.20) One of the most marked differences between animal cells and plant cells is that

- **A.** plant cells usually have one or more vacuoles.
- **B.** animal cells ordinarily have a nucleolus within the nucleus.
- **C.** animal cells have their nuclear chromatin attached to the linin fibers.
- **D.** nucleoplasm is unique to the animal cell.
- **E.** plant cells usually have relatively thick, rigid walls.

28. (1.20) Which one of the following is characteristic of the Elodea cell but *not* of a cheek lining cell?

A. Nucleus. **B.** Cytoplasm. **C.** Cell wall.
D. Cell membrane. **E.** Protoplasm.

Item 29 deleted.

30. (1.20) Plasma membranes are termed differentially permeable, because they permit

- **A.** certain molecules to enter the cell and exclude others.
- **B.** only water molecules to enter and leave the cell.
- **C.** only substances in solution to pass through.
- **D.** small molecules to pass through while large molecules are excluded.

After each item number on the answer sheet, blacken space:

- **A,** if the item in column 1 is of greater magnitude than the item in column 2.
- **B,** if the item in column 2 is of greater magnitude than the item in column 1.
- **C,** if the two items are of equal magnitude.

	1	2
31. (1.20)	The importance of the nucleus in the transmission of hereditary units.	The importance of the cytoplasm in the transmission of hereditary units.
32. (1.20)	The relationship between plasma membrane and chromatin.	The relationship between nuclear membrane and chromatin.
33. (1.20)	The characteristic of irritability as applied to the cell wall.	The characteristic of irritability as applied to the plasma membrane.
34. (1.20)	The ability of a plant cell to divide.	The ability of an animal cell to divide.
35. (1.20)	The likelihood of a prominent vacuole in animal cells.	The likelihood of a prominent vacuole in plant cells.
36. (1.20)	The likelihood of chloroplastids in animal cells.	The likelihood of chloroplastids in plant cells.
37. (1.20)	The likelihood of cytoplasm as living protoplasm.	The likelihood of the nucleus as living protoplasm.
38. (1.20)	The function of the nucleus as a controlling and coordinating structure of the cell.	The function of the cytoplasm as a controlling and coordinating structure of the cell.
39. (1.20)	The likelihood that the plasma membrane will act as a membrane whose permeability remains unchanged during the life of the cell.	The likelihood that the cell wall will act as a membrane whose permeability remains unchanged during the life of the cell.
40. (1.20)	The level of organization of a system.	The level of organization of an organ.
41. (1.20)	The likelihood of a centrosome in plant cells.	The likelihood of a centrosome in animal cells.

42. (1.20) The portion of the protoplasm in which most of the energy-releasing chemical changes occur in a cell is the

A. nucleus. **B.** plasma membrane.
C. cytoplasm. **D.** chloroplast. **E.** vacuole.

43. The part of the cell which contains materials of use to
(1.20) the cell or which functions in the process of elimination is the

A. nucleus. **B.** plasma membrane.
C. vacuole. **D.** chloroplast. **E.** centrosome.

44. The secreted non-living, outer covering of the cells of
(1.20) plants is the

A. plasma membrane. **B.** cytoplasm.
C. chloroplast. **D.** cell wall. **E.** centrosome.

45. The term "differentially permeable" is used to describe
(1.20) which of the following parts or constituents of a typical living cell?

A. Nucleus. **B.** Cytoplasm. **C.** Centrosome.
D. Plasma membrane. **E.** Chromatin net.

46. The protoplasm of a typical living cell in the human
(1.20) body contains carbohydrates, fats, proteins, enzymes, mineral salts, and water. Most important in the development of new protoplasm are the

A. carbohydrates. **B.** fats. **C.** proteins.
D. enzymes. **E.** mineral salts.

47. The outer layer of protoplasm which serves as a selec-
(1.20) tive agent in determining what materials enter and leave the cell is the

A. nucleus. **B.** plasma membrane.
C. chloroplast. **D.** cell wall. **E.** centrosome.

48. The portion of the protoplasm which is chiefly respon-
(1.20) sible for coordinating and controlling the chemical and physical changes which result in the production of more protoplasm is the

A. nucleus. **B.** plasma membrane.
C. cytoplasm. **D.** chloroplast. **E.** cell wall.

49. The part of the cell generally associated with the trans-
(1.20) mission of hereditary traits is the

A. nucleus. **B.** plasma membrane.
C. cytoplasm. **D.** chloroplast. **E.** centrosome.

50. Certain of the cytoplasmic structures which are barely
(1.20) visible with the microscope are distinguished from one another in terms of

A. chemical composition as revealed by affinity for different stains.
B. distribution through the cytoplasm, or localization in various regions of the cytoplasm.
C. role in the economy of the cell.
D. all of the above. **E.** none of the above.

51. With the aid of an ordinary microscope, one could de-
(1.20) termine whether a region of the cytoplasm of a cell was in a sol or gel state by

A. seeing whether the protein molecules are elongated or rounded.
B. seeing whether the smallest visible particles are nearly stationary or more freely mobile.
C. determining how darkly the region stains with cytoplasmic dyes.
D. measuring the amount of carbon dioxide evolved in that region.
E. comparing the degree of transparency of that region with the degree of transparency of other regions of the cytoplasm.

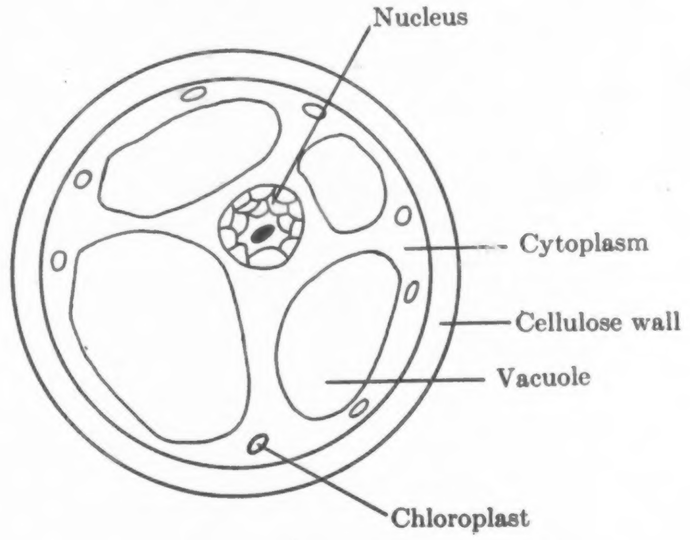
52. A cell which is 25 microns in diameter is
(1.20)

A. larger than **B.** smaller than
C. approximately the same size as a similar cell which is 1/2500 inch in diameter.

53. The statement "The cell is the unit of structure, func-
(1.30) tion, and reproduction of the living organism" represents the

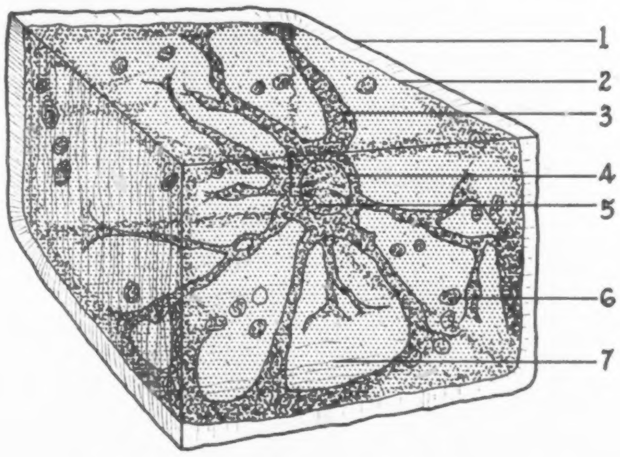
A. organismal concept. **B.** definition of a cell.
C. protoplasmic concept. **D.** species concept.
E. cell principle.

54. Examine the diagram below; then select the response
(2.20) which applies.



A. The sketch is a diagrammatic representation of an animal cell.
B. The sketch represents a plant cell.
C. The sketch is a drawing of epithelial tissues.
D. The sketch represents the cross-section of a grass stem.
E. The sketch represents the cross-section of a germinating seed.

Items 55 - 64. Blacken the space on the answer sheet corresponding to the number representing the best answer.



55. Regulates the passage of materials into and out of the
(2.20) cell.

A. 1 **B.** 2 **C.** 3 **D.** 4 **E.** 5

56. Carries the hereditary units.
(2.20)

A. 3 **B.** 4 **C.** 5 **D.** 6 **E.** 7

57. Has an essential part in the manufacture of glucose.
(2.20)

A. 1 **B.** 2 **C.** 4 **D.** 6 **E.** 7

58. The place where most of the chemical activity of the cell occurs.
(2.20)

A. 2 **B.** 3 **C.** 5 **D.** 6 **E.** 7

59. The structure on the outside which characterizes this type of cell.
(2.20)

A. 1 **B.** 2 **C.** 3 **D.** 4 **E.** 5

60. The non-living portion of the cell that is not found in the animal cell.
(2.20)

A. 1 **B.** 2 **C.** 3 **D.** 4 **E.** 5

61. The part of the cell where stored food such as starch grains or fat droplets are found.
(2.20)

A. 1 **B.** 2 **C.** 3 **D.** 4 **E.** 5

62. The part of the cytoplasm that contains a high concentration of water and dissolved materials.
(2.20)

A. 2 **B.** 3 **C.** 5 **D.** 6 **E.** 7

63. Structure which functions to give rigidity to the cell.
(2.20)

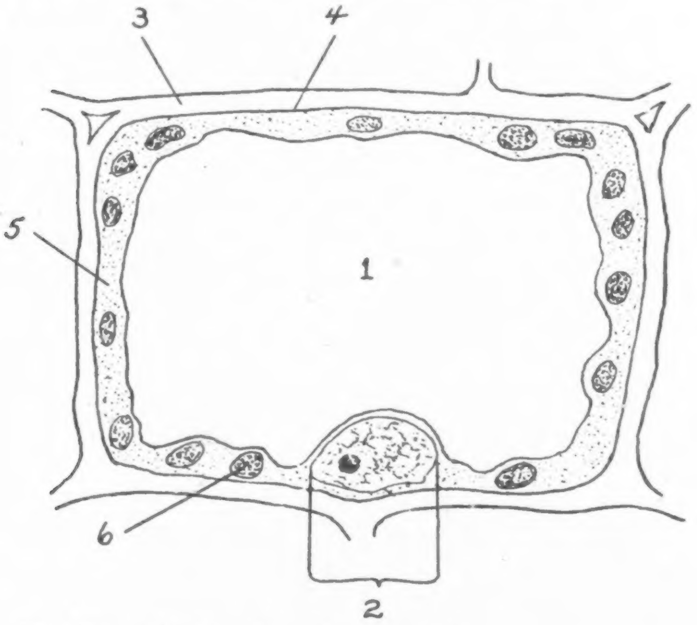
A. 1 **B.** 2 **C.** 4 **D.** 6 **E.** 7

64. Is responsible for the life and coordinating activities of the cell.
(2.20)

A. 1 **B.** 2 **C.** 3 **D.** 4 **E.** 5

Items 65 - 69.

After each item number on the answer sheet, blacken the *one* lettered space which designates the correct answer.



65. The cell pictured in the diagram is
(2.20)

A. an animal cell. **B.** a plant cell.

66. We know this to be true because of
(1.20)

A. 1 alone. **B.** 3 alone. **C.** 6 alone.
D. 3 and 6. **E.** 2 and 5.

67. The part of this cell which is composed almost entirely of cellulose is
(2.20)

A. 1 **B.** 2 **C.** 3 **D.** 4 **E.** 5

68. The most homogeneous protoplasm in this cell is in the part designated by
(2.20)

A. 1 **B.** 2 **C.** 3 **D.** 4 **E.** 5

69. Transmission of hereditary characteristics and photosynthesis are functions *respectively* of
(2.20)

A. 2 and 6. **B.** 5 and 6. **C.** 2 and 5.
D. 2 and 4. **E.** 1 and 2.

70. The protoplasm of a typical living cell in the human body contains carbohydrates, fats, proteins, enzymes, mineral salts, and water. Most important in the structure of new protoplasm are the
(1.20)

A. carbohydrates. **B.** fats. **C.** proteins.
D. enzymes. **E.** mineral salts.

71. The term "differentially permeable" is used to describe which of the following parts or constituents of a typical living cell?
(1.20)

A. Nucleus. **B.** Cytoplasm. **C.** Centrosome.
D. Plasma membrane. **E.** Chromatin.

72. Protoplasm exhibits the properties of growth, reproduction, and response. The property of response is most evident in the protoplasm of the cells of which of the following tissues in man?
(1.20)

A. Muscle. **B.** Nerve. **C.** Epithelial.
D. Adipose. **E.** Vascular.

73. Oxidation occurs at a relatively low temperature in living organisms, because
(1.20)

A. less energy is released than in the burning of the same amount of material in air.
B. oxidation occurs more slowly in living organisms than during combustion.
C. some organisms are cold-blooded, others have a constant body temperature.
D. energy in living organisms is conducted away more rapidly.
E. enzymes facilitate the oxidation occurring in living organisms.

74. The characteristic of protoplasm to construct new protoplasm from simple materials, to oxidize food materials, and to break down living matter is referred to by the general term
(1.10)

A. anabolism. **B.** osmosis. **C.** catabolism.
D. metabolism. **E.** symbiosis.

DIRECTIONS: Cytoplasm is considered to be a complex colloidal mixture. *Blacken* answer space

A. if the statement is *true*, and represents a *reason* for considering cytoplasm to be colloidal.
B. if the statement is *true*, but *irrelevant* to establishing the colloidal nature of cytoplasm.
C. if the statement is false.

75. Cytoplasm is translucent, rather than perfectly transparent.
(3.00)

76. Certain objects, such as chloroplasts and starch granules, are visible in the cytoplasm of some cells.
(3.00)

77. Protein molecules are of colloidal size.
(3.00)

78. Cytoplasm, in plant cells especially, includes vacuoles which are completely empty.
(3.00)

79. Fat droplets can be seen in the cytoplasm of some cells viewed with the microscope.
(3.00)

7. *Tissues—Animal and Plant*

TISSUES—ANIMAL AND PLANT

After the number on the answer sheet which corresponds to that of each of the following exercises, blacken the one lettered space which designates the *best* answer.

1. (1.10) A group of cells of like structure and origin performing a specific function is

A. an organ. **B.** a tissue. **C.** a system.
D. an organism. **E.** an aggregate of cells.

2. (1.10) The structure in the cells that controls and regulates cell activities, and functions in transmission of heredity factors is the

A. nucleus. **B.** cytoplasm. **C.** plasma membrane.
D. vacuole. **E.** centrosome.

3. (1.10) Epithelial tissue is a type of

A. lining tissue. **B.** muscle tissue.
C. tissue conducting nervous impulses.
D. tissue producing growth in plants.
E. supporting tissue.

4. (1.10) Cartilage

A. binds bones together.
B. covers the ends of the bones.
C. binds the muscles to the bones.
D. composes much of the epidermis.
E. covers the muscles.

5. (1.10) Elastic tissue is a type of

A. epithelial tissue. **B.** connective tissue.
C. muscular tissue. **D.** nerve tissue.
E. parenchymatous tissue.

True-False

6. (1.10) The transformation of cartilage into bone is ossification.

7. (1.20) Which of the following cannot be classified as a tissue?

A. Nerve. **B.** Skin. **C.** Bone.
D. Cartilage. **E.** Epithelium.

True-False

8. (1.10) The dermis is the inner tissue layer of vertebrate skin.

9. (1.20) Which of the following plant tissues is similar in structure and function to the epithelial tissue of animals?

A. Meristem tissue. **B.** Epidermal tissue.
C. Parenchyma tissue. **D.** Vascular tissue.
E. Supporting tissue.

10. (1.20) The characteristic feature of epithelial tissue is that

A. it is always arranged in single layers of cells.
B. it is usually composed of large amounts of extracellular or non-living materials.
C. the shape of the cells is generally columnar.
D. one of its surfaces is usually exposed either to the exterior of the body or to the cavity of a hollow structure.

Items 11 through 14 give characteristic features of the tissues listed in the following key. Select the proper response for these items from this key.

KEY

A. Epithelial tissue **B.** Smooth muscle tissue
C. Nerve tissue **D.** Vascular tissue
E. Skeletal muscle tissue

11. (1.20) A fluid tissue.

12. (1.20) Composed of elongated cells with many nuclei.

13. (1.20) The unit cell is rounded or triangular and may have long attached fibers.

14. (1.20) This tissue as a rule is thin and sheetlike.

15. (1.20) In the following pair, blacken space **A** if the first element of the pair is definitely greater than the second; space **B** if the second is definitely greater than the first; and space **C** if the two are approximately equal.

A. Striations in a voluntary muscle.
B. Striations in an involuntary muscle.

16. (1.20) The principle of "division of labor" in biology involves

A. the production of varied agricultural crops.
B. competition between organisms for the needs of life.
C. differentiation of cells into tissues having different functions.
D. growth so that there are more cells to do the work.
E. all of these.

17. (1.20) Which of the following statements is *not* true of epithelial cells?

A. They are most frequently found deep within the tissues.
B. They comprise very largely the coverings and linings of parts of the body.
C. Some epithelial cells form the secreting parts of glands.
D. Some epithelial cells possess fine hairlike cilia.
E. Some epithelial cells are stratified into layers.

18. (1.20) The development of vascular tissue in plants involves the

A. disappearance of protoplasm from the mature xylem.
B. overlapping of the pointed ends of fiber cells.
C. disappearance of chloroplasts from the parenchyma cells.
D. loss of hair-like projections from epidermal cells.
E. formation of a waxy layer on epidermal tissue.

After the exercise number on the answer sheet blacken the one lettered space which designates the most similar structure, condition, or process.

19. (3.00) The relationship between cells and tissues:

A. The relationship between an enzyme and the substance digested.
B. The relationship between organs and systems.
C. The relationship between carbohydrates and fats.
D. The relationship between ectoderm and entoderm.
E. The relationship between the liver and the gall bladder.

8. *Organs and Organ Systems—Their Functions*

ORGANS AND ORGAN SYSTEMS—THEIR FUNCTIONS

For items 1 - 4 use the following key.

KEY

A. Organism. B. Organ. C. Cell.
D. Protoplasm. E. None of the above.

1. (1.10) Name given to any living thing.

2. (1.10) The unit of structure and function of living things.

3. (1.10) A group of tissues organized into a structure performing a specialized function.

4. (1.10) The living material.

5. (1.10) When tissues are grouped on the basis of related function, the resulting grouping is known as a (an)

A. organism. B. organ system. C. organ.
D. tissue culture. E. functional unit.

Blacken space A, if the item is true of a *cell*; B, if true of a *tissue*; C, if true of an *organ*; D, if true of a *system*; E, if true of an *organism*.

6. (1.10) A structural unit having cytoplasm and nucleus as its essential parts.

7. (1.10) A structure composed of at least three different tissues, which work together to pump blood.

8. (1.10) The lining of the stomach which is made up of a layer of cells similar in structure, function and origin.

9. (1.10) A unit capable of carrying on metabolism, growing, reproducing itself and adjustment to environmental stimuli.

10. (1.10) A unit made up of nostrils, throat, trachea, and lungs which work together in the breathing process.

True-False

11. (1.10) A flexor is a muscle causing extension or straightening out of a member such as the arm.

12. (1.10) A type of skeleton found in insects.

13. (1.10) A bone in the leg.

14. (1.10) A connecting tissue between bone and muscle.

15. (1.10) A type of plant movement.

16. (1.10) A muscle tissue found in the heart.

17. (1.10) The end of a muscle away from the center of the body.

18. (1.10) A name for the protective covering of the plant body

19. (1.10) The name for a normal curve or flexure in the backbone.

A. Auxin
B. Cardiac
C. Chitinous
D. Clavicle
E. Cranial
F. Humerus
G. Insertion
H. Integument
I. Origin
J. Osseous
K. Pelvic
L. Smooth
M. Tendon
N. Tibia
O. Turgor

Although the number of kinds of tissues is small, they can be combined in various ways to produce organs of different structures and functions.

Directions: **For each of the following organs or parts of organs, blacken answer space**

A–if it is essentially a *tube with muscle* capable of affecting the diameter of the tube.
B–if it is essentially a *tube or sac* without muscle in the walls.
C–if it is essentially a solid mass of cells penetrated by blood vessels.
D–if it is essentially a sheet of cells.
E–if none of the foregoing descriptions of tissue-arrangements applies.

20. (1.10) Capillary.

21. (1.10) Small intestine.

22. (1.10) Skeletal muscle.

23. (1.10) Epidermis.

24. (1.10) Nerve.

25. (1.10) Vein.

26. (1.10) Spinal cord.

27. (1.20) Of these bodily functions the skin does *not* play a major part in

A. protecting underlying organs and tissues from bacterial infection.
B. regulating body temperature through evaporation of perspiration.
C. the elimination of wastes.
D. supporting organs and tissues.
E. transmission of sympathetic nerve impulses.

For items 28 to 33 select from the key the body system of which the organ forms a part. In those cases wherein an organ serves two or more systems select the one of primary importance.

KEY

A. Digestion. B. Excretion. C. Reproduction.
D. Nervous. E. Supportive.

28. (1.20) Glomerulus.

29. (1.20) Sternum.

30. (1.20) Pylorus.

31. (1.20) Duodenum.

32. (1.20) Ganglia.

33. (1.20) Lacteals.

34. (1.20) The color of the skin in normal people is due primarily to pigment granules in the

A. horny layer of the skin.
B. basal layer of the dermis.
C. basal layers of the subcutaneous tissue.
D. innermost layer of the epidermis.

After each item on the answer sheet, blacken space (Items 35 - 57)

A–if the item refers to the structure or the function of the kidney.
B–if the item refers to the structure or the function of the liver.
C–if the item refers to the structure or the function of the skin.
D–if the item refers to more than one of the above organs.
E–if the item refers to none of the above organs.

35. (1.20) **Essential ingredients of old red blood cells, including iron, are salvaged for future use.**

36. (1.20) **Approximately a million units, each composed of a vascular portion, a glomerulus, an epithelial portion, and a tubule, make up the essential part of this organ.**

37 It functions in excretion.
(1.20)

38. Its tactile corpuscles respond to change in pressure.
(1.20)

39. Ideally designed for filtration of water and dissolved
(1.20) substances from plasma.

40. An organ producing a plasma protein, fibrinogen, con-
(1.20) cerned with clotting.

41. Normal function results in stability of the internal en-
(1.20) vironment.

42. The villi increase the absorptive area of the organ.
(1.20)

43. Some of the old worn-out red corpuscles are destroyed
(1.20) by phagocytes in this organ.

44. The vertebrates' first line of defense against bacterial
(1.20) invasion.

45. Chief storage organ for iron in man.
(1.20)

46. The organ which produces enzymes capable of acting
(1.20) on starch.

47. The organ in man which is provided with numerous
(1.20) accessory structures, such as hair, nails, and glands of various kinds.

48. The organ which normally returns practically all (59/60)
(1.20) of the water previously extracted from the plasma.

49. Vagus impulses interact and inhibit the respiratory
(1.20) centers.

50. The chief storage organ for reserve glycogen.
(1.20)

51. The organ in which all of the glucose from the filtrate
(1.20) is normally reabsorbed as it passes down the tubule.

52. The organ which removes water and excretable solutes
(1.20) from the body.

53. An organ of temperature control.
(1.20)

54. An organ continuous with several mucous membranes.
(1.20)

55. After the accomplishment of the first contraction there
(1.20) is no contraction to any stimulus however strong.

56. Organ-producing substances which prevent pernicious
(1.20) anemia.

57. Organic phosphates (ATP) are transformed into phos-
(1.20) phates and unknown organic compounds yielding energy.

58. The largest gland man possesses is the
(1.20)

A. pituitary. **B.** thyroid. **C.** bladder.
D. liver. **E.** spleen.

For items 59-68 select from the key the most closely related phrase and mark the corresponding answer space.

KEY

A. A striated voluntary muscle tissue.
B. A striated involuntary muscle tissue.
C. A tissue composed of a firm but elastic material.
D. A tissue composed of a firm but inelastic material.
E. A tissue, the cells of which are free, that is, not bound together.

59. A tissue resting only at very short, regular, and closely
(1.20) spaced intervals throughout the life of the animal.

60. The tissue composing the major part of the patella.
(1.20)

61. Forms much of the skeleton of new-born infants and in
(1.20) adults supports the external ear.

62. A tissue made up of cells, certain types of which are not
(1.20) nucleated.

63. A tissue, the cells of which move the bones of the body.
(1.20)

64. Muscle tissue ordinarily making up the greater part of
(1.20) the mass of the body.

65. A tissue, the matrix of which is composed largely of
(1.20) calcium phosphate.

66. A tissue whose function concerns, in part, the destruction
(1.20) by ingestion of bacteria injurious to the body.

67. A tissue which is capable of contracting quickly but
(1.20) needs frequent rest periods.

68. The tissue supporting the end of the nose.
(1.20)

69. Organs are grouped into systems on the basis of
(1.20)

A. related functions.
B. nearness of location to each other in the body of the organism.
C. the order of their appearance in the embryo.
D. taxonomic classification. **E.** common structure.

70. The vocal cords of mammals are found within the
(1.20)

A. pharynx. **B.** larynx. **C.** bronchus.
D. upper esophagus. **E.** glottis.

71. Of the following, the one which is neither a bone of the
(1.20) arm nor of the leg is the

A. humerus. **B.** ilium. **C.** patella.
D. phalanx. **E.** ulna.

72. Which of the following is a bone of the leg?
(1.20)

A. Humerus. **B.** Ulna. **C.** Metacarpal.
D. Radius. **E.** Fibula.

73. A man broke his clavicle, that is, he broke his
(1.20)

A. head. **B.** great toe. **C.** jaw. **D.** leg.
E. shoulder.

74. Since the mucous membrane is continuous, nasal infec-
(1.20) tion may spread through the Eustachian tubes to the

A. lungs. **B.** middle ears. **C.** frontal sinuses.
D. larynx. **E.** esophagus.

75. The *uvula* is which of the following?
(1.20)

A. A structure hanging from the posterior free border of the soft palate.
B. Another name for the vermiform appendix.
C. The duct leading from the liver to the small intestine.
D. The lower portion of the epididymis.
E. The embryonic root of a seed.

76. In the following pair, blacken space A if the first element
(1.20) of the pair is definitely greater than the second; space B if the second is definitely greater than the first; and space C if the two are approximately equal.

A. Number of bones in the middle ear.
B. Number of semi-circular canals in the ear.

77. Which of the following is the first to break the proper
(1.20) sequence?

A. Humerus. **B.** Radius. **C.** Metacarpals.
D. Carpals. **E.** None of these.

78. What is the function of tendons?
(1.20)

A. They bind bones together at joints.
B. They cover the ends of bones.
C. They attach muscles to bones.
D. They support parts of the body such as the trachea, external ear, or end of the nose.
E. They form shock-absorbing pads between the vertebrae.

79. What is the effect of fatigue on muscle tonus?
(1.20)

A. It is usually increased by fatigue.
B. It is usually decreased by fatigue.
C. It is usually unaffected by fatigue.
D. It is destroyed by fatigue.
E. It has no relationship to fatigue.

30. The interiors of the alimentary tract and lungs are not
(2.20) considered to be inside the body because

A. the activities of these organs are controlled by the medulla.
B. these structures are lined with endothelial cells.
C. they are readily accessible in surgical operations.
D. substances in these organs are not part of the internal environment of the cells and tissues of the body.
E. they are innervated by the peripheral nerves.

81. As we walk our bones and muscles exemplify which
(2.20) simple machine?

A. Wedge. **B.** Lever. **C.** Wheel. **D.** Screw.
E. All of these.

82. The interior of the lungs of a higher vertebrate is some-
(3.00) times considered as being exterior to the organism. Such an opinion might reasonably be based on the fact that

A. the content of the lungs is continuous with the external environment.
B. in order to reach the blood, oxygen molecules must pass through the cells composing the capillary walls.
C. the composition of the contents of the lungs is independent of the metabolism of the cells of the organism.
D. simple physical laws are adequate to explain the exchange of gases between blood and lungs.
E. the water content of the air in the lungs is the same as that of the air surrounding the animal.

Items 83 - 88.

In many of the organs of the mammalian body, the anatomical arrangement of parts within it gives a hint as to the type of role which that organ serves in the body.

Directions: For each of the following numbered organs or parts of organs, blacken the answer space corresponding to the parts, in the list below, whose arrangement gives evidence for the organ's special function in the body.

Structural Components of Organs

A. Contractile fibers.
B. Blood vessels (leading to it and within it).
C. Ducts (tubes other than blood vessels), and the passages into which the ducts open.
D. Valves.

If none of the above structural clues to function are afforded by the organ, blacken answer space **E.**

Note: In some organs, *more than one* of the above structural components is arranged so as to give evidence as to the role of the organ. In such cases, give *each and every* clue.

83. Heart. **84.** Lungs. **85.** Salivary gland.
(3.00) (3.00) (3.00)

86. Calf muscle of the leg. **87.** Any nerve.
(3.00) (3.00)

88. Any organ primarily concerned with regulating the com-
(3.00) position of the blood.

9. *Characteristics of Living Organisms*

CHARACTERISTICS OF LIVING ORGANISMS

1. (1.10) The ameba uses its pseudopodia primarily in the process of

A. digestion. B. locomotion. C. excretion.
D. food storage. E. enzyme secretion.

Items 2 - 11.

KEY

A. present in Amoeba. B. present in Paramecium.
C. present in both. D. present in neither.

2. (1.10) contractile vacuole.

3. (1.10) ectoplasm.

4. (1.10) endoplasm.

5. (1.10) flagella.

6. (1.10) food vacuoles.

7. (1.10) mouth.

8. (1.10) oral groove.

9. (1.10) pseudopodia.

10. (1.10) separate macro- and micronucleus.

11. (1.10) trichocysts.

12. (1.20) The frog differs from man in which of the following?

A. Salivary glands are absent in frog.
B. Thyroid gland is absent in frog.
C. Pancreas does not secrete insulin in frog.
D. Adrenal glands are absent in frog.

13. (1.20) The body plan of the spider is best characterized by

A. head, thorax, and abdomen.
B. head and trunk. C. head, trunk, and tail.
D. head-thorax, and abdomen.
E. head, and thorax-abdomen.

14. (1.20) The frog and the amoeba both carry on which of the following processes?

A. Respiration. B. Digestion. C. Metabolism.
D. Two of the foregoing. E. All of the foregoing.

15. (1.20) The question, "What is life?"

A. has been answered to the satisfaction of most scientists.
B. can never be answered adequately so most scientists feel that there is little value in trying to study the problem.
C. has been studied for generations by biologists who have provided us with only a partial answer to the problem.
D. should be relatively easy to answer because the differences between living, non-living, and dead are sharp and clear-cut.
E. should not concern man since it is out of his province.

For items 16-17 select from the key the principle which applies.

KEY

A. All protoplasm has the power of movement.
B. All protoplasm is irritable.
C. Metabolic processes occur in living things.
D. Living things are adapted to their environments.
E. Cells are the units of structure and function in organisms.

16. (1.20) Reports of frogs or other animals sealed up in cement work and remaining alive for many years are doubtless untrue.

17. (1.20) Cells are surrounded by a plasma membrane which controls, within certain limits, the movement of water into and from the cells.

18. (1.20) Indicate which statement describes most completely the function of protoplasm in living cells.

A. Protoplasm is responsible for cell motility.
B. Protoplasm responds to environmental stimuli.
C. Protoplasm uses oxygen and releases carbon dioxide.
D. Protoplasm carries on the life processes of the cell.
E. Protoplasm controls the movement of substances into and out of the cell.

19. (1.20) Living organisms are believed to be characterized by all *except* which one of the following?

A. Growth. B. Response to stimuli.
C. Movement. D. Metabolism.
E. Spontaneous generation.

20. (1.20) Theoretically, the smallest thing among the following that reproduces its kind is a

A. protozoan. B. bacterium. C. sex cell.
D. chromosome. E. gene.

21. (1.20) Which one of the five phrases listed below best completes the following: "All organisms are composed of cells . . .

A. and their constituent parts."
B. and their products."
C. and their descendants."
D. their predecessors and descendants."
E. and their capacity for mitosis."

22. (1.20) Which of the following circulatory mechanisms is characteristic of all organisms?

A. Diffusion. B. Gastrovascular mechanism.
C. Flame cell system. D. xylem-phloem mechanism.
E. Blood vascular system.

23. (1.20) The best concept of the physical nature of protoplasm is that of a

A. jelly like substance in which are dissolved proteins, fats, and carbohydrates.
B. mixture of several solutions containing salts, proteins, fats, and carbohydrates.
C. complex colloidal system of salts, fats, carbohydrates, enzymes, proteins, and vitamins.
D. watery substance containing small amounts of enzymes, fats, carbohydrates, and salts.

24. (1.20) Among the following statements select the one which is not true.

A. The protoplasm of every living cell is identical with that of every other living cell.
B. Protoplasm is a complex colloidal system.
C. Protoplasm is composed of chemical elements all of which may be found in non-living systems.
D. Among the common constituents of protoplasm are water and mineral salts.
E. The protoplasm within a cell shows division of labor.

25. (1.20) One of the major differences between a living and a non-living system is that the living system

- **A.** is composed of chemical elements different from those in non-living systems.
- **B.** may increase in volume.
- **C.** can produce more of itself from non-living materials.
- **D.** is composed of molecules all of which are characteristic of living materials.
- **E.** reacts to a change in the environment.

Arrange the items in the following lists in a logical order, e.g., time, increasing size, increasing complexity, as indicated by the nature of the list. After each item number on the answer sheet, blacken space

A. for first in order. **B.** for second in order.
C. for third in order. **D.** for fourth in order.
E. for fifth in order.

From outside a cell inward the structures are, successively,

26. (1.20) Protoplasm.
27. (1.20) Tissues.
28. (1.20) Cells.
29. (1.20) Systems.
30. (1.20) Organism.
31. (1.20) Nuclear membrane.
32. (1.20) Plasma membrane.
33. (1.20) Cytoplasm.
34. (1.20) Chromatin.

Arrange the items in the following lists in a logical order, i.e. increasing size, increasing complexity, or in order of succession from outside toward center.

After each item number on the answer sheet, blacken space

A. for first in order. **B.** for second in order.
C. for third in order. **D.** for fourth in order.
E. for fifth in order.

35. (1.20) Organ.
36. (1.20) Organism.
37. (1.20) Tissue.
38. (1.20) Cell.
39. (1.20) System.
40. (1.20) Cork.
41. (1.20) Phloem.
42. (1.20) Pith.
43. (1.20) Zylem.
44. (1.20) Cambium.
45. (1.20) Earthworm.
46. (1.20) Hydra.
47. (1.20) Paramecium.
48. (1.20) Frog.
49. (1.20) Man.

50. (1.20) All except which one of the following are considered to be characteristics of living organisms?

A. Spontaneous generation. **B.** Cellular organization.
C. Metabolic activity. **D.** Responsiveness to stimuli.
E. Continuity of form from one generation to the next.

Many of the exchanges between a plant and its environment and between an animal and its environment are similar, while some are peculiar to each.

Directions: For each of the following "exchanges" with the environment, blacken answer space

- **A.** if it characterizes a *green plant,* but not an animal.
- **B.** if it characterizes an *animal,* but not a green plant.
- **C.** if it occurs for *all green plants and all animals.*
- **D.** if it occurs for *some* green plants and animals.
- **E.** if it occurs for *neither* green plants nor animals.

51. (1.20) Organic nitrogen compounds must enter the organism from the environment.

52. (1.20) The organism absorbs oxygen from the environment.

53. (1.20) The organism absorbs carbon dioxide from the environment.

54. (1.20) More glucose molecules diffuse out of the whole organism than into it.

55. (1.20) Energy-rich carbon compounds must enter the organism from the environment.

56. (1.20) The "vital" properties of protoplasm are

- **A.** diffusion, osmosis, adsorption.
- **B.** Brownian movement, surface tension, osmosis.
- **C.** osmosis, reproduction, reactiveness.
- **D.** irritability, metabolism, reproduction.
- **E.** irritability, reactiveness, diffusion.

57. (1.20) Which of the following processes is involved in the normal locomotor mechanism in *Amoeba proteus?*

A. Sol-gel and gel-sol transformation.
B. Contraction of the plasmagel.
C. Adhesion to substrate. **D.** All of the above.

58. (1.20) Which of the following statements gives the most adequate explanation as to how living things grow?

- **A.** Cells divide and multiply in order to increase the size of the organisms.
- **B.** The body needs a variety of tissues and organs to carry out its multiplicity of functions.
- **C.** Hormones probably stimulate cells to divide and differentiate when certain critical ratios between volume and surface are reached.
- **D.** In living organisms growth is necessary to maintain the species.
- **E.** There is an interdependence among living things on the earth. Growth is necessary in order to sustain a balance between the various species in the world of living things.

Multicellular organisms presumably arose from single-celled organisms, especially from colonial single-celled organisms.

Directions: For each of the items, 59 - 62, blacken answer space

- **A.** if it is characteristic of multicellular organisms as opposed to colonies of single-celled organisms (aggregates simpler than Volvox).
- **B.** if it is characteristic of *colonies of single-celled organisms* as opposed to multicellular organisms.
- **C.** if it is *always true of both* multicellular organisms and colonies of single-celled organisms.
- **D.** if it is *sometimes* but not always true of both.
- **E.** if it is *never* true of either.

59. (1.20) Certain cells are incapable of respiration.

60. (1.20) Certain cells must absorb amino acids as such through their plasma membranes.

61. (1.20) There are no cells or organs specialized to remove carbon dioxide and other wastes from the system.

62. (1.20) The function of providing food substances in a form usable by all the cells in the system is relegated to a fraction of the cells.

For items 63-72 mark space

- **A.** if *a* is included within or constitutes a part of *b*.
- **B.** if *b* is included within or constitutes a part of *a*.
- **C.** if neither *a* nor *b* is included within or constitutes a part of the other.

63. (1.20)
a. Enzyme.
b. Saliva.

64. (1.20)
a. Seed.
b. Cotyledon.

65. (1.20)
a. Heart.
b. Auricle.

66. (1.20)
a. Carnivore.
b. Mammal.

67. (1.20)
a. Abdomen of man.
b. Semi-circular canals.

68. (1.20)
a. Hydra.
b. Protozoa.

69. (1.20)
a. Gene.
b. Chromosome.

70. (1.20)
a. Hemoglobin.
b. Red corpuscle.

71. (1.20)
a. Xylem.
b. Vascular bundle.

72. (1.20)
a. Lichen.
b. Algae.

73. (1.20) An animal differs from a plant in that an animal

- **A.** has cells which do not secrete a cellulose cell wall.
- **B.** possesses simpler tissues.
- **C.** responds to stimuli more slowly.
- **D.** possesses chlorophyll in its cytoplasm.
- **E.** is capable of manufacturing its own food.

74. (1.20) Life as we know it

- **A.** is probably the only form of life-activity that is possible in the universe.
- **B.** is not explainable in terms of physical and chemical reactions.
- **C.** is dependent on the versatile combining powers of the elements carbon and nitrogen.

75. (1.20) Indicate which statement describes most completely the function of protoplasm in living cells.

- **A.** Protoplasm is responsible for cell motility.
- **B.** Protoplasm carries on the life processes of the cell.
- **C.** Protoplasm uses oxygen and releases carbon dioxide.
- **D.** Protoplasm responds to environmental stimuli.
- **E.** Protoplasm controls the movement of substances into and out of the cell.

76. (1.20) Of the following characteristics, which one is common to *all* living cells?

- **A.** Cell membrane.
- **B.** Nuclear material scattered throughout the cell.
- **C.** Cellulose cell wall. **D.** Chloroplasts.
- **E.** More than one of these.

77. (1.20) The frog and the amoeba both carry on which of the following processes?

A. Respiration. **B.** Digestion. **C.** Metabolism.
D. Two of the above. **E.** All of the above.

78. (1.20) Homologous structures include (2 answers)

- **A.** structures with the same origin.
- **B.** structures with the same function but different origins.
- **C.** the wing of a housefly and the wing of a bat.
- **D.** the front leg of a cat and the wing of a bird.
- **E.** the trunk of a tree and the trunk of an elephant.

For each of the items, 79 - 81, blacken the answer space which corresponds to the letter of every passage which correctly completes the statement.

79. (1.20) During its entire life the normal animal

- **A.** takes in more carbon dioxide molecules than it gives off.
- **B.** takes in more water molecules than it gives off.
- **C.** takes in more carbon atoms than it gives off.
- **D.** takes in more nitrogen atoms than it gives off.

80. (1.20) The living substance which is found in both plant and animal cells is

A. keratin. **B.** thyroxin. **C.** pepsin.
D. protoplasm. **E.** chlorophyll.

81. (1.20) Both plants and animals are capable of all except which one of the following?

A. Food storage. **B.** Carbohydrate synthesis.
C. Assimilation. **D.** Respiration.
E. Response to stimuli.

For items 82-95 select from the key the most appropriate or closely related phrase and mark the corresponding answer space.

KEY

- **A.** Common to all life.
- **B.** Characteristically found only in plants.
- **C.** Characteristically found only in animals.
- **D.** Characteristically found in neither animals nor plants.

82. (1.20) Digestion.

83. (1.20) Growth continues throughout life.

84. (1.20) Reproduction.

85. (1.20) Respiration.

86. (1.20) A nervous system.

87. (1.20) Movement.

88. (1.20) Excretion.

89. (1.20) Absorption.

90. (1.20) Cell protoplasm enclosed within cellulose walls.

91. (1.20) Secretion.

92. (1.20) Tissues bathed in salt solution.

93. (1.20) Growth.

94. (1.20) Assimilation.

95. (1.20) Irritability (responsiveness, sensitivity).

96. (1.20) Which of the following could not be used as a basis for distinguishing between plants and animals?

- **A.** Cellulose in cell walls.
- **B.** Possession of chlorophyll.
- **C.** Possession of protoplasm.
- **D.** Possession of a nervous system.
- **E.** Source of food.

97. (1.20) Which one of the following is common to both plants and animals?

A. Cellulose cell walls. **B.** Nervous system.
C. Protoplasm.
D. The immediate source of their food.
E. None of these.

Items 98-104 represent principles or situations in the field of biological science. Select from the key list the term that is most nearly related to each statement and blacken the appropriate space on the answer sheet.

KEY

A. Metabolism. B. Irritability.
C. Reproduction. D. Evolution. E. Ecology.

98. (1.30) No living organism exists on earth in a state of freedom. All organisms are connected indissolubly and uninterruptedly.

99. (1.20) If ice water is introduced at one end of a microscope slide, paramecia on the slide will tend to accumulate at the end where room temperature still prevails.

100. (1.30) Spontaneous, largely self-regulated movement is characteristic of living bodies.

101. (1.30) Complex, incessant physico-chemical changes are constantly occurring in all living protoplasm.

102. (1.20) The type of animal life in a particular society depends upon the plant life which prevails, and the latter, in turn, depends upon the climatic conditions existing in the area in question.

103. (1.30) While new living bodies are born only from pre-existing ones, from time to time new generations arise differing from preceding ones.

104. (1.30) Primarily as a result of Pasteur's experiments, the theory of *spontaneous generation* was succeeded by the theory of *biogenesis.*

105. (2.10) Which one of the following is not and never was an organism?

A. Something that is dead.
B. Something that is living.
C. Something that is non-living.
D. An ameba. **E.** A bacterium.

10. Plant Structure and Functioning

PLANT STRUCTURE AND FUNCTIONING

1. (1.10) The tissues of plants are in general not pliable when compared to animal tissues because

A. the cells are larger.
B. the cells generally have larger vacuoles.
C. the cells have cytoplasmic membranes.
D. the cell walls contain cellulose.
E. the protoplasm of the cells is stiffer.

2. (1.10) The root cap seems to function in

A. regulation of water uptake.
B. production of the epidermis.
C. production of root hairs.
D. dissolution of soil particles.
E. protection of growing point.

3. (1.10) Tissue in which the cells retain their ability to divide is called

A. meristem. B. sclerenchyma. C. phloem.
D. collenchyma. E. pith.

4. (1.10) The membrane on the surface of the cytoplasm is called

A. plasmodesma. B. vascule membrane.
C. middle lamella. D. plasma membrane.
E. cytosome.

5. (1.10) Botany had its origin in

A. describing plants so that early medicine men could identify the ones with the most famous healing powers.
B. continuing the arguments first proposed by Aristotle.
C. the careful descriptions of plants composed by early herbalists following careful examination resultant from pure curiosity.
D. the dissertations composed by monks concerning the mentioning of specific plants in the Bible.
E. cataloging the plants that were useful to man as a source of food.

6. (1.10) An individual who is an accepted authority in the field of functions of living things and their interactions may be most appropriately classified as

A. anatomist. B. taxonomist. C. physiologist
D. physicist. E. geologist.

7. (1.10) That aspect of biology primarily concerned with structure and form of living things is

A. taxonomy. B. morphology. C. physiology.
D. ecology. E. limnology.

8. (1.10) The cambium of a plant functions in

A. protection. B. support. C. food storage.
D. producing new cells. E. photosynthesis.

9. (1.10) The stomates of the leaf

A. control the entry of gases into the air spaces of the leaf.
B. allow gases to enter or leave the air spaces of the leaf.
C. possess chloroplasts.
D. prevent excess water loss from the leaf.
E. prevent carbon dioxide from entering the leaf.

10. (1.10) Trees attain their height by

A. uniform elongation of their trunks between the ground and their branches.
B. greater elongation at the base of the trunk.
C. growth added between the roots and the trunk.
D. both the elongation of the trunk and the branches.
E. terminal growth only.

11. (1.10) Higher plants generally absorb nitrogen from the soil in the form of

A. nitrogen molecules. B. urea. C. nitrates.
D. proteins. E. amino acids.

12. (1.10) Tissue of a plant which actively divides to produce enlargement of the plant is called

A. parenchyma. B. epidermis. C. meristem.
D. schlerenchyma. E. epithelium.

13. (1.10) The movement of raw materials and carbohydrates from one region to another within a plant is known as

A. transmutation. B. translocation. C. transpiration.
D. transplantion. E. transfusion.

14. (1.10) A seed might be described as a transformed

A. egg. B. female gametophyte. C. ovule.
D. ovary. E. male gametophyte.

15. (1.10) Cellulose is a

A. component of chlorophyll.
B. material found in cell walls of plants.
C. substance found only in trees.
D. type of enzyme. E. plant hormone.

16. (1.10) Of the following minerals, those which are *not* essential to normal plant growth are (2 answers)

A. calcium. B. bismuth. C. magnesium.
D. aragonite. E. potassium.

17. (1.10) Which one of the following is not a part of the leaf blade?

A. Petiole. B. Cuticle. C. Vein.
D. Stomates. E. Palisade layer.

For each of the plants listed in items 18 - 25, indicate by use of the key below the most useful portion of the plant.

KEY

A. Root. B. Stem. C. Leaf. D. Fruit.
E. Cell sap.

18. (1.10) Potato.

19. (1.10) Horseradish.

20. (1.10) Watermelon.

21. (1.10) Sugar cane.

22. (1.10) Tobacco.

23. (1.10) Hemp.

24. (1.10) Chard.

25. (1.10) Sweet potato.

26. The root hairs are
(1.10)

A. thick-walled hollow spindles which have no enclosed protoplasm.
B. small organs each containing one vascular bundle.
C. lateral projections of the xylem tubes from the central core of the root, which protrude from the surface of the root.
D. chains of cells whose adjoining cell walls are perforated.
E. thin-walled extensions of single cells, in which the nucleus can often be found near the tip of the extension.

True-False (Item 27)

27. Undifferentiated growing tissue in plants is termed
(1.10) meristem.

28. The structures used for transport of solutions in plant
(1.10) stems are called

A. lenticels. **B.** veins. **C.** stomates.
D. cambium cells. **E.** vascular bundles.

29. The passage of air into and out of a leaf is
(1.10)

A. accomplished by free diffusion through the epidermal cells.
B. effected in a manner similar to that by which inorganic ions enter the roots.
C. regulated by guard cells at the openings to the air spaces in the leaf.
D. greatest when the amount of water transpired is least.
E. facilitated chiefly by the expansion and contraction of the leaf due to temperature changes.

30. The *direction* of motion of dissolved substances in the
(1.10) xylem tubes in the stem is
A. chiefly upward. **B.** chiefly downward.
C. dependent upon the amount of light reaching the leaves.
D. chiefly outward (radial).

31. Turgor movements are accomplished by
(1.10)

A. increased oxidation stimulated by auxins.
B. increased secretion of extracellular digestive enzymes.
C. change in the quantity of water contained in certain cells.
D. change in the length of contractile protein molecules in certain cells.
E. increase in the volume of water between certain cells.

32. Most plant cells lack
(1.10)

A. cell membranes. **B.** centrosomes. **C.** plastids.
D. nuclei. **E.** cellulose.

33. The embryonic root of the plant is known as the
(1.10)

A. meristem. **B.** cotyledon. **C.** hypocotyl.
D. radicle. **E.** plumule.

34. A tree may be said to be composed of organs because
(1.10) it is made up of

A. cortex, stele, and cambium.
B. roots, stem, and leaves.
C. photosynthetic, conductive, and sustentative tissues.
D. none of the structures mentioned above—i.e., for none of these reasons.

35. Common white flour is obtained from that part of the
(1.10) wheat seed called

A. coleoptile. **B.** epithelium. **C.** embryo.
D. germ. **E.** endosperm.

36. Meristematic tissues are
(1.10)

A. absent in most dicotyledons. **B.** embryonic.
C. senile. **D.** composed of highly modified cells.
E. used by the plant for protection.

37. The epidermis of a leaf is
(1.10)

A. on the upper side of the leaf only.
B. on the lower side of the leaf only.
C. on both sides of the leaf.
D. the entire leaf except for the veins.
E. replaced on leaves by a waxy surface coating.

38. Root hairs occur on the following part of the root:
(1.10)

A. the root cap. **B.** the growing point.
C. the entire root tip beyond the first lateral roots.
D. in the region of elongation.
E. in the region of maturation.

39. Tissue in which the cells retain their ability to divide is
(1.10) called

A. meristem. **B.** sclerenchyma. **C.** phloem.
D. collenchyma. **E.** pith.

40. The ascent of sap in a tall tree may best be explained
(1.10) by what theory?

A. Atmospheric pressure. **B.** Capillarity.
C. Pumping. **D.** Cohesion of water.
E. Root pressure.

41. The chief biological function served by the endosperm
(1.20) stored in corn kernels is that it

A. provides food for the corn embryos when the seeds germinate.
B. facilitates species survival by widespread seed dispersal.
C. provides food for livestock.
D. furnishes a source of food for the respiring dormant seeds.

42. The gills of mushrooms are
(1.20)

A. specialized layers bearing basidia.
B. organs of respiration.
C. specialized layers producing poisons.
D. photosynthetic tissues. **E.** sex organs.

43. Autumnal abscission of leaves benefits deciduous trees
(1.20) primarily in

A. slowing respiration.
B. eliminating waste products.
C. conserving water. **D.** allowing the tree to rest.
E. furnishing humus.

44. Evidence for the translocation of foods in the phloem
(1.20) has been obtained by measurements of

A. diurnal fluctuation in stem diameter.
B. leaf size. **C.** the effect of girdling.
D. annual rings. **E.** root pressure.

45. (1.20) Plants are relatively lacking in freedom of movement and flexibility because

A. they contain chlorophyll.
B. they contain cellulose.
C. they can respond to stimuli.
D. they manufacture their own food.
E. they probably preceded animals on the earth.

Items 46 - 55 refer to the green plant. After each item number on the answer sheet, blacken space

A. if the item is associated primarily with the root.
B. if the item is associated primarily with the stem.
C. if the item is associated primarily with the leaf.
D. if the item is associated with more than one of the above.

46. (1.20) Amino acids are synthesized here.

47. (1.20) Photosynthesis occurs chiefly here.

48. (1.20) The water used in photosynthesis enters the plant here.

49. (1.20) Contains a layer of embryonic cells known as cambium.

50. (1.20) The epidermis is specialized for the absorption of materials.

51. (1.20) Glucose is converted to starch here.

52. (1.20) Veins form a firm framework around which are softer tissues.

53. (1.20) Reserve food is stored here

54. (1.20) Most carbon dioxide used in food manufacture enters the plant here.

55. (1.20) Supporting tissue is associated with conducting tissue to form vascular bundles.

(Items 56 - 64 have been deleted.)

65. (1.20) Indicate which *one* of the following is *never* a function of the stem of plants.

A. Conduction. **B.** Food storage.
C. Photosynthesis. **D.** Support.
E. None of the above.

66. (1.20) One of the principal results of annual leaf-fall in deciduous trees is that

A. respiration ceases entirely until spring.
B. winter food-making activities are taken over by the roots.
C. the trees obtain their entire food supply from the soil during the winter months.
D. water is conserved in the winter.
E. the trees survive without food during the dormant winter stage.

67. (1.20) Which one of the following is common to roots, stems, and leaves?

A. Cambium. **B.** Absorptive hairs.
C. Epidermal cells. **D.** Terminal cap.
E. Stomates.

68. (1.20) Which of the following tissues provides a continuous conducting pathway from the root of a plant to the leaves?

A. Xylem. **B.** Parenchyma. **C.** Cambium.
D. Epidermis. **E.** Endodermis.

69. (1.20) Phloem differs from xylem in that the xylem

A. has thinner-walled cells.
B. carries sugars downward from the leaves.
C. is primarily a reproductive tissue.
D. carries water from the roots to the leaves.
E. is tissue which stores food.

Item 70 deleted.

71. (1.20) Plants in general are able to use

A. nitrates from the soil. **B.** ammonia from the air.
C. nitrites from the soil.
D. nitrogenous compounds in the protoplasm of intac dead organisms.
E. free nitrogen gas of the air.

For items 72 through 74 select the best response from the following key:

KEY

A. Meristem. **B.** Epidermal. **C.** Parenchyma.
D. Supporting. **E.** Vascular.

72. (1.20) Some cells of this tissue have slender projections that extend between the soil particles.

73. (1.20) This tissue has the ability to divide repeatedly.

74. (1.20) This tissue is used as one basis for the classification of plants.

75. (1.20) The foliage of deciduous trees develops from

A. branches of all types.
B. branches under ½ in. thick.
C. twigs two years of age and over.
D. twigs formed the previous year.

76. (1.20) The stomatal openings in leaves

A. allow carbon dioxide to diffuse into the interior of the leaf.
B. are found in both the upper and lower epidermis of corn, bean, and geranium.
C. constitute a part of the palisade parenchyma.
D. permit plants to absorb water from the air when the soil is unusually dry.
E. allow water loss in the form of drops by a process known as guttation.

77. (1.20) Which of the following is *not* an underground stem?

A. Carrot. **B.** Onion. **C.** Potato.
D. Gladiolus. **D.** Iris.

78. (1.20) The term most closely related to bulb, rhizome, tuber, stolon is

A. leaf. **B.** stem. **C.** trunk.
D. adventitious root. **E.** tap root.

In item 79, a structural or functional condition is to be compared with other conditions below it. Blacken the answer space corresponding to the number of the *one* condition which most closely resembles the first stated condition.

79. (1.20) The most conspicuous biological value of a seed:

- **A.** The most conspicuous biological value of a spore.
- **B.** The most conspicuous biological value of differentiation or gametes.
- **C.** The most conspicuous biological value of sexual differentiation of individuals.

Items 80 and 81 refer to the following experiment:

Experiment: A number of corn grains were carefully planted "upside down" (i.e., with the end from which the root normally grows pointing up).

80. (1.20) Several weeks after sprouting or germinating

- **A.** both roots and stems grew downward.
- **B.** roots and stems ceased growing.
- **C.** roots grew downward and stems upward.
- **D.** roots grew upward and stems downward.
- **E.** both roots and stems grew upward.

81. (1.20) Because (referring to item 80)

- **A.** roots grow down ward and stems upward.
- **B.** stems could not reach sunlight which is necessary for photosynthesis.
- **C.** gravity influences the growth of both stems and root.
- **D.** differential growth rates of root and stem are responsible.
- **E.** the plant could not otherwise survive.

82. (1.20) Under which of the following conditions do the stomata usually open?

- **A.** When the air temperature decreases.
- **B.** When darkness sets in.
- **C.** When the osmotic pressure in the guard cells decreases.
- **D.** When turgor in the guard cells increases.
- **E.** When the sugar content of the guard cells decreases.

83. (1.20) Which of the following is *not* composed of cells?

A. Epidermis. **B.** Spongy parenchyma.
C. Palisade parenchyma. **D.** Stomata.
E. Border parenchyma.

84. (1.20) One of the two sperm nuclei descending the pollen tube initiates development of the embyro, while the second sperm nucleus initiates development of

- **A.** the petals of the flower.
- **B.** the leaves of the plant.
- **C.** food used later by the embryo.
- **D.** a rudimentary embyro which later disintegrates if the first one is successful.
- **E.** the stem of the plant.

85. (1.20) In the following pair, blacken space **A** if the first element of the pair is definitely greater than the second; space **B** if the second is definitely greater than the first; and space **C** if the two are approximately equal.

- **A.** Number of chloroplasts in a mushroom.
- **B.** Number of chloroplasts in a bread mold.

86. (1.20) In the listed pair of conditions, processes, etc., mark for each item:

Space **A** if the two increase or decrease together.
Space **B** if one increases as the other decreases.
Space **C** if there is no relationship between the two conditions.

- **A.** Number of wood vessels formed in one year by a perennial plant.
- **B.** Age of the plant.

For item 87, blacken the answer space which corresponds to the letter of every passage which correctly completes the statement.

87. (1.20) During its entire life the normal green plant

- **A.** takes in more oxygen molecules than it gives off.
- **B.** takes in more water molecules than it gives off.
- **C.** takes in more oxygen atoms (i.e., oxygen in any form) than it gives off.
- **D.** takes in more carbon dioxide molecules than it gives off.

88. (1.20) In the following pair, blacken space **A** if the first element of the pair is definitely greater than the second; space **B** if the second is definitely greater than the first; and space **C** if the two are approximately equal.

- **A.** Extent to which green plants depend upon the soil for carbohydrates.
- **B.** Extent to which green plants depend upon the soil for minerals.

89. (1.20) One of the chief functions of stomates is to

- **A.** store starch which accumulates as a result of photosynthetic activity.
- **B.** reinforce and give rigidity to the leaves.
- **C.** allow gases to diffuse into and out of the internal regions of the leaves.
- **D.** serve as temporary storage compartments for chloroplasts.
- **E.** convert glucose into starch.

90. (1.20) Higher plants have fewer organs than higher animals. Which of the following might be a possible reason?

- **A.** Animals need more organs than plants to carry out their more diversified functions.
- **B.** Animals are more active than plants.
- **C.** Higher animals have achieved a greater degree of specialization than higher plants.
- **D.** Higher plants possess embryonic tissue (meristem and cambium) which remains functional throughout the life span.
- **E.** Animals are exposed to more serious hazards than plants.

91. (1.20) Which of the following is capable of being transformed into all of the others?

A. Sieve tubes. **B.** Parenchyma. **C.** Cambium.
D. Fibers. **E.** Xylem.

92. (1.20) Which one of the following can give rise to all of the other four?

A. Growth-promoting hormone. **B.** Meristem.
C. Xylem. **D.** Phloem. **E.** Parenchyma.

93. Which one of the following can give rise to all the
(1.20) other four?

A. Xylem. B. Phloem. C. Cambium.
D. Parenchyma. E. Chloroplast.

94. A tree that is "hollow"
(1.20)

A. is always dead because the roots are no longer able to receive food through the medullary rays.
B. may continue to live if enough xylem is left to transport food to the roots.
C. is always dead because the phloem in the center of the trunk is destroyed thus cutting off transportation of food, manufactured in the roots, up to the leaves.
D. may continue to live if enough xylem is left to transport water and minerals from the roots to the leaves.
E. is always dead because the heartwood has been destroyed.

95. Which of the following best accounts for the fact that
(1.20) monocots do not have annual rings?

A. They have no xylem tissue.
B. They are not responsive to changes in temperature.
C. They grow at a fairly uniform rate throughout the year.
D. They are annuals, hence don't live long enough to show evidence of rings.
E. Cambium is lacking in the stem.

96. In a mature seed plant in early summer, large numbers
(1.20) of mitotic divisions occur

A. wherever a tissue is increasing in volume.
B. in limited regions in the root and stem, including some near the tips.
C. only in the cambium.
D. only in the phloem and xylem tissue.
E. in all tissues of the plant.

97. One significant difference between roots and stems is
(1.20) that

A. branch roots originate in the pericycle while branch stems do not.
B. stems are always above the ground while roots are always below the ground.
C. stems are positively geotropic while roots are negatively geotropic.
D. stems are sometimes used for storage while roots are never so used.
E. stems grow in both length and circumference while roots grow only in length.

For items 98 - 102 use the key list below to answer the following questions.

KEY

A. Respiration. B. Transpiration.
C. Photosynthesis. D. Transportation of food.
E. Transportation of water.

98. If oxygen is being given off by the plant, which of the
(1.20) above processes is most probably responsible?

99. If carbon dioxide is being given off, which is most
(1.20) probably responsible?

100. Which of the above ceases in total darkness?
(1.20)

101. Which one of the above is most directly affected by
(1.20) the opening and closing of the stomata?

102. Which of these never occurs in a fungus?
(1.20)

Items 103 - 108 are based on the key list below:

KEY

A. Photosynthesis. B. Respiration.
C. Starch synthesis. D. Protein synthesis.
E. Fat synthesis.

103. In which of the above processes is the energy source
(1.20) outside of the plant?

104. Which process occurs in every living cell in the plant?
(1.20)

105. Which process results in release of energy?
(1.20)

106. If the sun were blotted out, which process would cease
(1.20) immediately?

107. In which process are the nitrates of fertilizers utilized?
(1.20)

108. In which process is chlorophyll necessary?
(1.20)

For items 109 - 124 refer to the key list below in answering the following questions.

KEY

A. Cambium. B. Xylem. C. Phloem.
D. Pericycle. E. Epidermis.

109. Which of the above is responsible for the formation of
(1.20) cork?

110. Which of the above is lacking in a mature root?
(1.10)

111. Which of the above is largely composed of lignified
(1.10) cells?

112. Which of the above is largely composed of dead cells?
(1.10)

113. Which of the above is responsible for the formation of
(1.20) secondary tissues?

114. Which of the above is responsible for the formation of
(1.20) branch roots?

115. Which of the above transports water in the stem?
(1.20)

116. Which of the above first receives water from the soil?
(1.10)

117. Which of the above gives rise to root hairs?
(1.20)

118. Which of the above occurs just external to the wood?
(1.10)

119. Which of the above transports sugar?
(1.20)

120. Which of the above is present in vascular bundles of
(1.10) dicots but not in the bundles of monocots?

121. Which of the above contains sieve tubes?
(1.10)

122. Which of the above contains companion cells?
(1.10)

123. Which of the above contains tracheids?
(1.10)

124. (1.10) Which of the above contains vessels?

125. (1.20) Stomata are open in the morning because the

A. plant wants to get rid of water.
B. plant needs carbon dioxide.
C. guard cells are turgid.
D. guard cells are not turgid.
E. plant only "breathes" at night.

126. (1.20) Minerals diffuse into the cells of the plant root as they are needed. This statement is

A. true, because the minerals are carried in by the water.
B. false, because such minerals as nitrates enter through the stomata.
C. true, because a plant will not be able to live without all of the minerals in the soil.
D. false, because the diffusion of a mineral into a plant root cell depends upon a greater concentration of the substance in the soil solution than in the plant.
E. true, because the function of all elements in the plant is known and their deficiency can be described.

127. (1.20) Evidence for the translocation of foods in the phloem has been obtained by measurements of

A. diurnal fluctuation in stem diameter.
B. leaf size. **C.** the effect of girdling.
D. annual rings. **E.** root pressure.

128. (1.20) Autumnal abscission of leaves benefits deciduous trees primarily in

A. slowing respiration.
B. eliminating waste products.
C. conserving water. **D.** allowing the tree to rest.
E. furnishing humus.

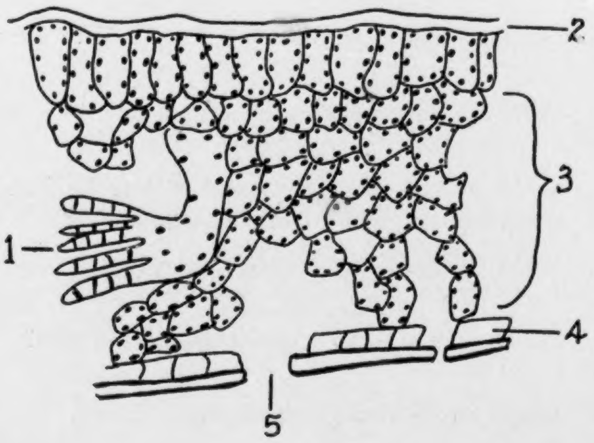
129. (1.20) The root cap seems to function in

A. regulation of water uptake.
B. production of the epidermis.
C. production of root hairs.
D. dissolution of soil particles.
E. protection of growing point.

130. (1.20) Rigidity of young herbaceous plants, such as lettuce, is due to the

A. woody tissue in the plant.
B. necessity for the stem to be erect.
C. presence of a xylem.
D. turgor pressure in the cells.

Items 131 - 135 refer to the diagram below.



Questions 131 through 135 are based on the diagram of the cross section of a leaf, on which certain structures are numbered. Identify the structures listed in the questions with those numbered on the diagram.

131. (1.20) Cuticle. **132.** (1.20) Stoma. **133.** (1.20) Xylem.

134. (2.20) Structure through which available nitrogen enters the leaf.

135. (2.20) Structure which may carry on photosynthesis.

136. (1.30) The ascent of sap in a tall tree may best be explained by what theory?

A. Atmospheric pressure. **B.** Capillarity.
C. Pumping. **D.** Cohesion of water.
E. Root pressure.

137. (2.20) A wire clothesline tied six feet from the ground around an 18 foot elm tree would be how high from the ground when the tree reached 36 feet?

A. Six feet. **B.** Nine feet. **C.** Twelve feet.
D. Eighteen feet. **E.** Twenty-four feet.

138. (2.20) If a carrot remains alive in the soil over winter it will resume growth the following spring. Its immediate source of food is obtained by

A. the process of photosynthesis.
B. absorption of nutrients from the soil.
C. absorbing materials accumulated by the decomposition of the previous season's leafy growth.
D. enzyme action on food stored in the carrot.
E. osmotic action produced by the higher concentration of water in the soil during the spring season.

139. (2.20) An instructor carefully peeled the outermost layer of tissue from the under surface of a green leaf. He placed a section of this tissue in a drop of water on a glass slide, covered it with a cover glass and placed it under the high-power objective of the microscope. He focused the microscope carefully and then announced that the students could observe the mounted tissue but cautioned them to avoid changing the adjustment. Acting according to directions, one of the students apparently observed the tissue and recorded descriptive statements in his notebook. Which of the following statements could *not* have been observed?

A. Sections of small hair-like projections appear on the upper surface of the tissue.
B. The upper cells in the epidermal tissue are thicker walled than the lower.
C. Some of the cells contain nuclei.
D. There are at least two guard cells at each stoma.
E. The cells in epidermal tissue are transparent.

140. (2.20) In vascular plants, materials are transported from one part of the plant to another through xylem and phloem elements. Which of the following statements is true of this?

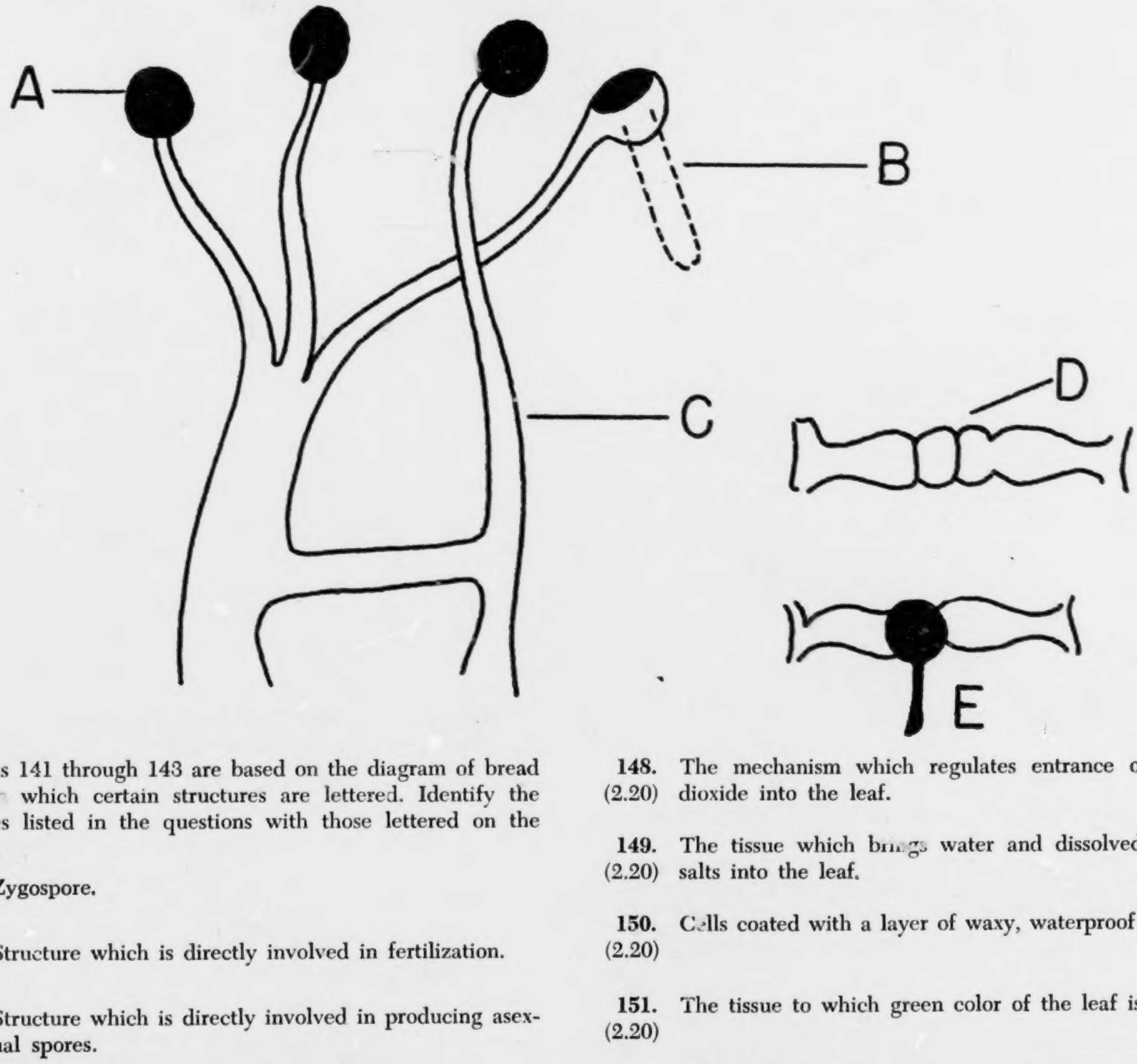
A. Organic foods through xylem and water and mineral salts through phloem.
B. Water and salts through xylem; organic foods through phloem.
C. Organic foods through both xylem and phloem continuously.

D. Organic foods and water through both xylem and phloem continuously.

E. Water through xylem in the daytime; organic foods through xylem at night.

Items 141 - 143.

Diagram of bread mold (Rhizopus)



Questions 141 through 143 are based on the diagram of bread mold, on which certain structures are lettered. Identify the structures listed in the questions with those lettered on the diagram.

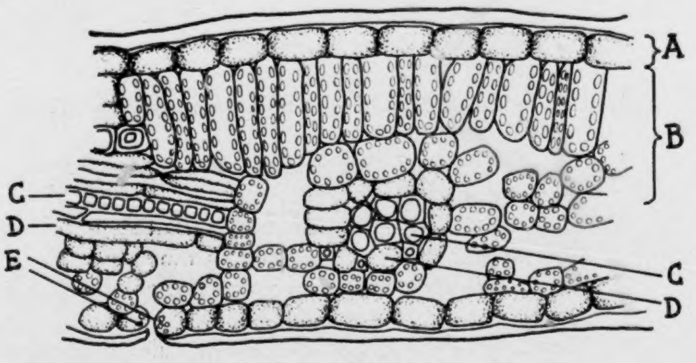
141. Zygospore.
(2.20)

142. Structure which is directly involved in fertilization.
(2.20)

143. Structure which is directly involved in producing asexual spores.
(2.20)

Items 144 - 158.

The diagram below represents the cross section of a leaf. After the number on the answer sheet which corresponds to each of the items following the diagram (144 - 158), blacken the *one* lettered space which designates the cells or tissue to which the item correctly refers.



144. Mesophyll or food-manufacturing cells.
(2.20)

145. A tissue which is called the xylem.
(2.20)

146. A transparent, protective tissue.
(2.20)

147. The tissue which carries away glucose manufactured in the green cells of the leaf.
(2.20)

148. The mechanism which regulates entrance of carbon dioxide into the leaf.
(2.20)

149. The tissue which brings water and dissolved mineral salts into the leaf.
(2.20)

150. Cells coated with a layer of waxy, waterproof material.
(2.20)

151. The tissue to which green color of the leaf is due.
(2.20)

152. The tissue which prevents too great evaporation and lessens the dangers of death from drying.
(2.20)

153. The tissue which is called the phloem.
(2.20)

154. The tissue of vein nearest the palisade layer.
(2.20)

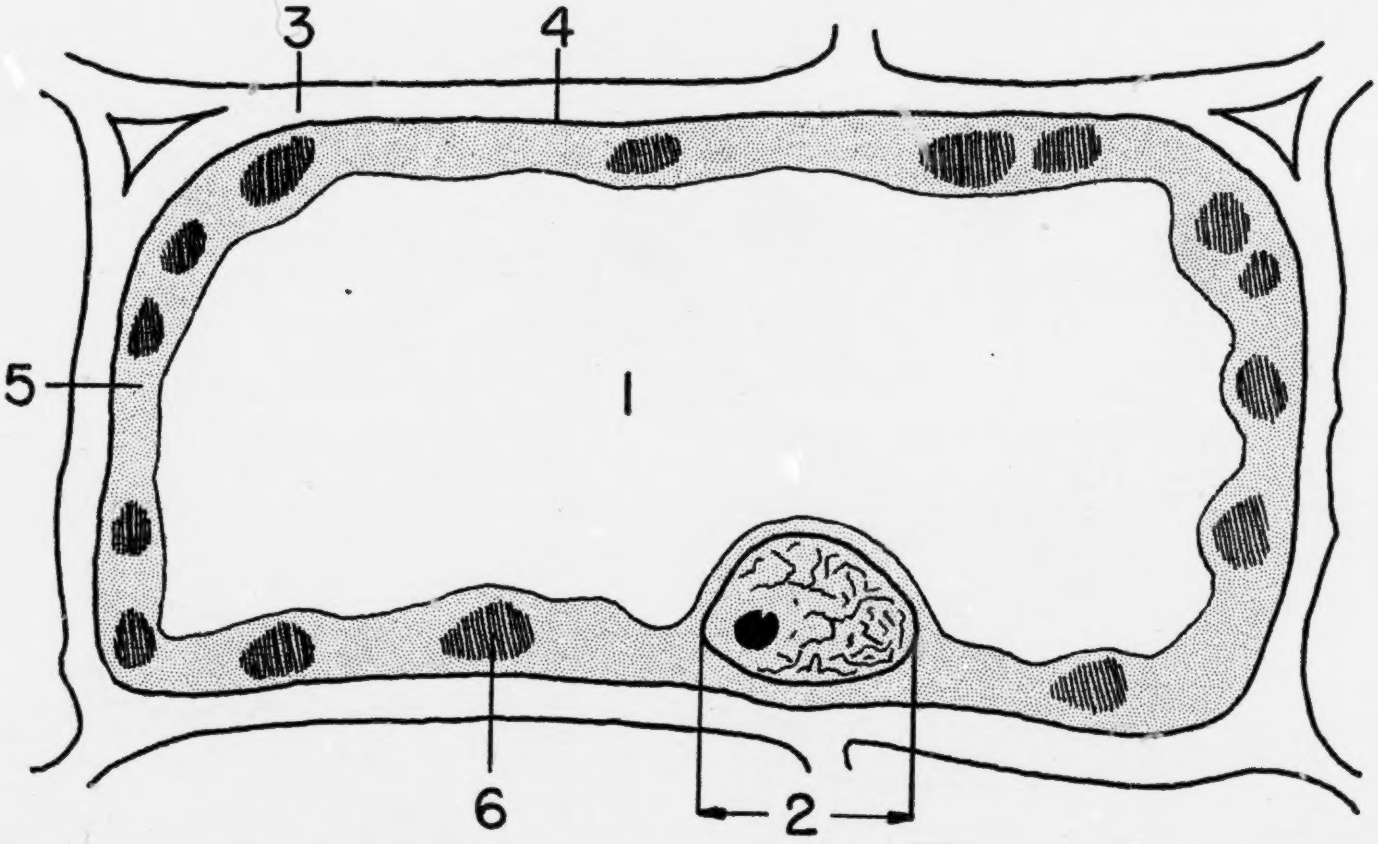
155. A conductive tissue whose function is to transport manufactured food through the plant.
(2.20)

156. Cells usually more abundant on the lower surface of the leaf than on the upper surface.
(2.20)

157. A tissue on many leaves which is covered with hairs.
(2.20)

158. The mechanism which regulates the exit of water from the leaf.
(2.20)

Items 159 - 168.



159. (1.20) Number 5 refers to

A. the nucleus. B. chromatin. C. the cell wall.
D. cytoplasm. E. plastids.

160. (1.20) Number 6 refers to

A. a chloroplast. B. a centrosome. C. a nucleus.
D. a vacuole. E. a chromosome.

161. (2.20) Entrance and exit of materials in and out of the cell is controlled by

A. 3. B. 4. C. 5. D. 6. E. 1.

162. (2.20) In plant cells, cellulose is the chief constituent of

A. 1. B. 2. C. 3. D. 4. E. 5.

163. (2.20) Most of the energy-releasing and protoplasm-building chemical reactions take place in

A. 5. B. 6. C. 2. D. 1. E. 4.

164. (2.20) Transmission of hereditary traits is made possible by

A. 2. B. 6. C. 3. D. 4. E. 5.

165. (2.20) The characteristic most often found in plant rather than animal cells is

A. 1. B. 2. C. 3. D. 4. E. 5.

166. (2.20) Water is most abundant in

A. 1. B. 2. C. 3. D. 5. E. 4.

167. (1.20) Number 3 refers to

A. the cell membrane. B. the cell wall.
C. cellulose. D. the cell itself.
E. none of the above.

168. (1.20) Cells can be seen

A. only in plants. B. only in animals.
C. by electron microscope only.
D. in all living things except human beings.
E. in all living things including human beings.

169. (2.20) If growing corn seedlings are fastened securely on the rim of a wheel that is rotated rapidly and constantly for a month,

A. the roots will grow inward toward the center of the wheel while the stems grow away from the center.
B. the roots will grow downward and the stems upward.
C. the roots will grow upward and the stems downward.
D. the roots will grow outward from the center of the wheel while the stems grow toward the center.
E. both roots and stems will grow outward away from the center of the wheel.

170. (2.20) It is a common observation that the autumnal coloration of leaves occurs at the time of the first frosts. It is the general belief that the frosts cause the coloration. Concerning this observation which of the following statements is most closely applicable?

A. The belief should be doubted because it is insufficiently controlled.
B. The observation is proof that frosts cause autumnal coloration of leaves.
C. This is not proof that autumnal coloration is caused by frost but that cool weather is the cause.
D. All common observations by non-scientists should be disregarded in scientific work.
E. The observation is not sufficiently valid because it has not been observed over a sufficiently long period of years.

Items 171 - 172. A vegetable garden was almost ruined by weeds, so the owner spread a layer of salt crystals over the entire garden. During the night there was a light rain.

171. (2.20) The owner found that

A. the weeds were all dead, but the vegetables were all alive.
B. nothing happened to either weeds or vegetables.
C. both weeds and vegetables were dead or wilted.
D. the vegetables were all dead, but the weeds were all alive.

172. (2.20) This result is explained by the fact that

A. salt solution has no effect on plants.
B. plasmolysis of the root cells was involved.
C. osmosis does not take place in weeds.
D. salt causes hemolysis in weeds, but not in vegetables.
E. salt solution stimulates peristalsis.

173. (2.20) In 1944 a lumberman cut across three living pine trees from different parts of a forest. All cuts were at waist height. The following lists give the arrangement of tree ring sequences for each tree, reading from the center of the tree outwards:

Tree 1	Tree 2	Tree 3
4 widely separated	31 normally spaced	17 normally spaced
8 closely spaced	7 widely separated	
42 normally spaced	8 closely spaced	
	42 normally spaced	

Blacken space A if the following statements relate to tree 1.
Blacken space B if the following statements relate to tree 2.
Blacken space C if the following statements relate to tree 3.
Blacken space D if the following statements relate to none of the trees.

A. The oldest tree.
B. The tree which lived through at least three climatically good and 8 poor years.
C. The tree with the least zylem.
D. The climate did not vary much since this tree was planted.
E. A tree which was planted during very good growing conditions.
F. A tree which was planted during average growing conditions.
G. The tree which was growing in 1900.
H. The tree which was growing in 1850.
I. The first two years of the twentieth century were not well suited for tree growth in this area.

Items 174 - 188. Refer to the diagrams in next column.

174. (2.20) The most-unspecialized (or embryonic) tissue is indicated by number

A. 11. B. 2. C. 14. D. 4. E. 15.

175. (2.20) The region of most-specialized tissues is indicated by number

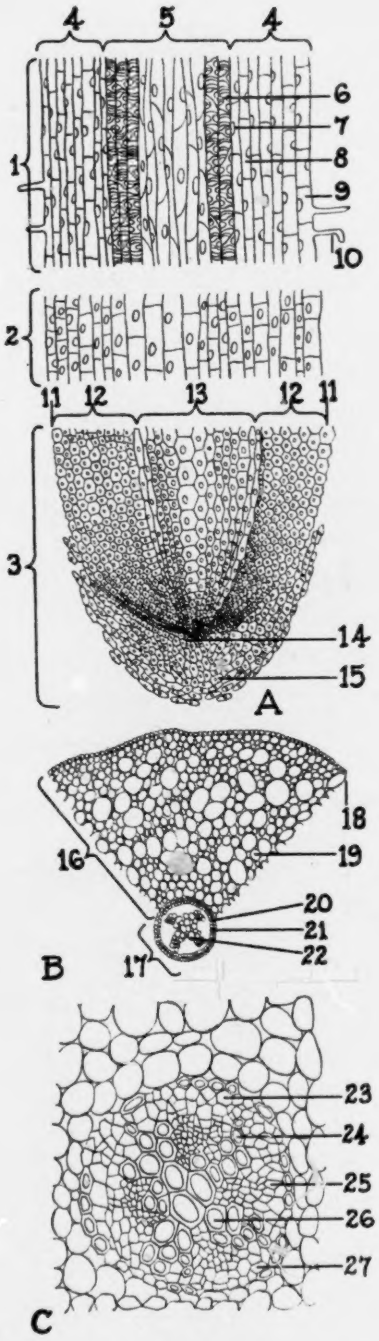
A. 1. B. 2. C. 3. D. 11. E. 12.

176. (2.20) Dead cells are located at number

A. 14. B. 2. C. 26. D. 4. E. 12.

177. (2.20) Modified epidermal cells are labelled number

A. 14. B. 6. C. 16. D. 10. E. 5.



178. (2.20) Growth of the root tip in length is provided for by tissue located at number

A. 1. B. 14. C. 15. D. 10. E. 9.

179. (2.20) The primary tissues are those which develop from number

A. 15. B. 14. C. 16. D. 4. E. 5.

180. (2.20) Xylem is labelled number

A. 23. B. 26. C. 25. D. 27. E. 20.

181. (2.20) The cortex is labelled number

A. 1. B. 2. C. 16. D. 18. E. 20.

182. (2.20) The region of elongation is labelled number

A. 1. B. 2. C. 3. D. 4. E. 5.

183. (2.20) When bark forms, the following tissues are lost: number

A. 24. B. 13. C. 22. D. 16. E. 5.

184. (2.20) The corky bark on older roots results from the activity of the layer of cells labelled number

A. 18. **B.** 19. **C.** 20. **D.** 4. **E.** 21.

185. (2.20) Branch roots develop from the layer of cells labelled number

A. 18. **B.** 19. **C.** 20. **D.** 21. **E.** 22.

186. (2.20) The number 17 in figure B indicates

A. parenchyma. **B.** cortex. **C.** stele.
D. cambium. **E.** pith.

187. (2.20) The number 26 in figure C indicates

A. a phloem cell. **B.** a parenchyma cell.
C. a xylem cell. **D.** an endodermal cell.
E. an epidermal cell.

188. (2.20) The principal function of cells labelled 9 and 10 in figure A is

A. growth of the root in circumference.
B. growth of the root in length.
C. absorption of water and mineral materials from the soil.
D. production of branch roots.
E. storage of starches and sugars.

For items 189 - 193 blacken the answer space corresponding to the single best answer (see figure below).

189. (2.20) Structure A functions to reduce

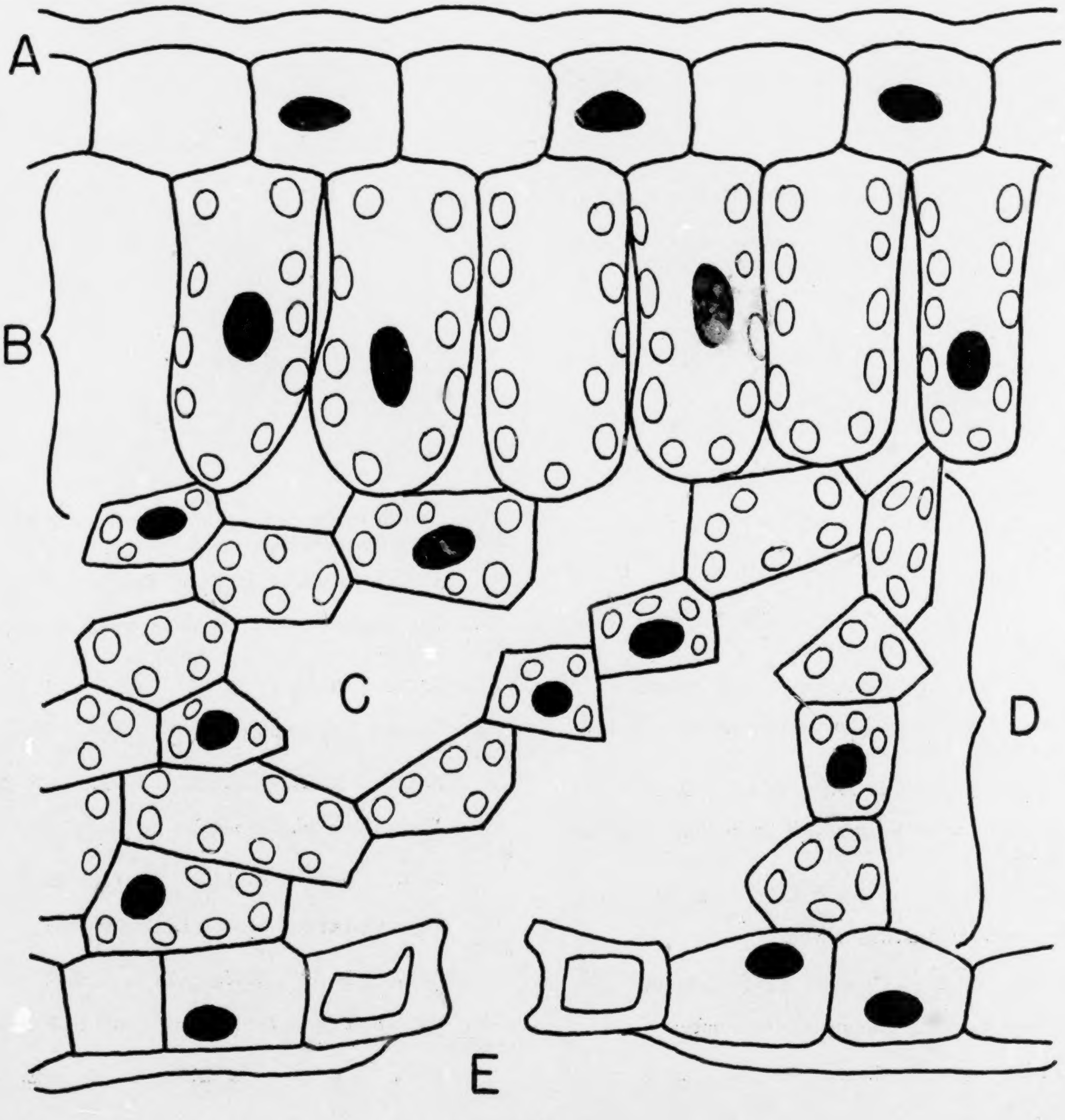
A. transpiration. **B.** guttation. **C.** respiration.
D. oxidation. **E.** fermentation.

190. (2.20) Structure B is

A. spongy tissue. **B.** vascular tissue.
C. palisade tissue. **D.** air space. **E.** chloroplast.

191. (2.20) Structure C is

A. spongy tissue. **B.** intercellular space.
C. sub-stomatal cavity. **D.** xylem.
E. none of the preceding.



192. Structure D is
(2.20)

A. palisade parenchyma. **B.** intercellular air space.
C. sub-stomatal cavity. **D.** spongy mesophyll.
E. vein.

193. Structure E is
(2.20)

A. guard cell. **B.** stoma. **C.** nematophore.
D. cuticle. **E.** none of the preceding.

Items 194 - 202 refer to the following experiment.

A gardener had heard that beans sprout better when planted in the "dark of the moon." He planned to test the truth of the rumor by experimentation. He prepared two rows in his garden and planted one row when the moon was full and the second row two weeks later when the new moon had not yet made its appearance. He returned to his garden in two weeks and counted the number of bean plants in the "light of the moon" row. This number was 37. Two weeks later he counted 37 plants in the "dark of the moon" row.

194. This gardener kept very complete records of conditions
(3.00) during the experiment. Of the following data that which has least value to the experiment would be

A. average temperature—
"Light" row—68°F.; "Dark" row—67°F.
B. soil moisture—
"Light" row—22%; "Dark" row—21%.
C. average sunlight per day—
"Light" row—8.4 hr.; "Dark" row—8.5 hr.
D. number of seeds planted—
"Light" row—46; "Dark" row—46.
E. yield at harvest—
"Light" row—13 lbs.; "Dark" row—15 lbs.

195. If we assume that the gardener began his experiment on
(1.20) the inference that there was some connection between moonlight and seed germination, the results obtained can best be stated as

A. an hypothesis. **B.** a theory.
C. a principle. **D.** a law. **E.** facts.

After the gardener had harvested his crop of beans he studied his observations and recorded certain possible tentative conclusions in his notebook. Evaluate these possible tentative conclusions (items 196 - 202) according to the following key.

KEY

A. The data obtained from this experiment is alone sufficient to justify a conclusion pertinent to the experiment.
B. The data indicates results that are contrary to accepted knowledge regarding seed germination.
C. Of significance to the gardener but bears no relationship to seed germination.
D. Goes beyond the data of this experiment and conflicts with accepted knowledge.
E. Goes beyond the data of this experiment but is in general accord with accepted knowledge.

196. Seeds will germinate satisfactorily at an average tem-
(2.20) perature of 67.5°F. if other conditions are satisfactory.

197. The beans planted in the "light of the moon" owe their
(2.20) decreased yield to presence of moonlight.

198. The phase of the moon is a more important factor than
(2.20) soil moisture in determining seed germination.

199. If all other factors affecting seed germination are to
(2.20) remain constant, the amount of seed needed for planting in the "dark of the moon" is equal to the amount needed for planting when the moon is full.

200. Beans planted in the "dark of the moon" will germinate.
(2.20)

201. Beans planted in the "dark of the moon" will never
(2.20) germinate regardless of soil conditions.

202. In this experiment the "dark of the moon" row yielded
(2.20) better than the "light of the moon" row.

Items 203 and 204 refer to the following experiment:

Experiment: A young tree, 6 feet high, with its lowest branch just 4 feet above the ground, was allowed to grow until the tree had doubled in total height.

203. The same branch is
(3.00)

A. still 4 feet above the ground,
B. now about 6 feet above the ground,
C. now 8 feet above the ground,
D. now 10 feet above the ground,
E. now more than 10 feet above the ground,

204. because
(2.20)

A. vertical growth of a stem is restricted to a zone near its tip.
B. most growth occurs at the top, but considerable growth occurs at all points.
C. each portion of the tree grows at the same rate.
D. most of the growth takes place at the ground level.
E. the cambium extends the entire length of the tree.

205. The relationship between carbon dioxide and stomates
(3.00) is comparable to the relationship between water and which one of the following?

A. Glucose. **B.** Osmosis. **C.** Root hairs.
D. Cellular respiration. **E.** Xylem.

206. A beaver gnawed completely around a birch tree, but
(3.00) did not proceed further to fell the tree. It was noticed that the leaves retained their normal appearance for several days, which were hot, after which the leaves began to wither and turn brown. The tree died. It can be concluded that the most peripheral region which it is certain the beaver had left functional was

A. the phloem. **B.** the cambium.
C. the xylem. **D.** the bark. **E.** the pith.

207. In view of the function of a leaf, one would expect
(3.00) usually to find a leaf oriented so that

A. the side on which the midrib is, is toward the sun.
B. its smooth flat side is parallel to the sun's rays.
C. its smooth flat side is perpendicular to the sun's rays.
D. the midrib is perpendicular to the ground.
E. the midrib points to the sun.

208. Cut branches in a vase of water can remain "fresh" for
(3.00) days due to

A. the maintenance of turgor pressure.
B. the high concentration of inorganic ions in water.
C. the higher temperature of the room.
D. the free entry of water into the open ends of both phloem and xylem tubes.
E. their lower rate of respiration in the room.

209. (3.00) A seed was placed in a dark moist chamber until it showed signs of germinating by pushing two white tips through the seed coat. Of these, the stem could be distinguished from the root soonest by noticing which tip

A. became green first. **B.** had leaves.
C. became covered with fine hairs.
D. bent upward; which, downward.
E. contained specific stem auxins and which contained root auxins.

210. (3.00) Flax roots, from which the stems have been severed, are unable to grow in nutrient solutions in which complete flax plants can grow, unless the solutions contain vitamin B_1. This means that

A. the flax plant is incapable of synthesizing vitamin B_1.
B. vitamin B_1 contains elements other than carbon, hydrogen, oxygen, and nitrogen.
C. the synthesis of vitamin B_1 requires some class of substances as substrate other than carbohydrates, fats, or proteins.
D. the cells of the flax root do not undergo oxidative metabolism.
E. the leaves and/or stem of the flax soon synthesize vitamin B_1.

211. (3.00) The function to which its shape adapts the root hair is most similar to the function to which its *similar shape* adapts a(n)

A. villus in a mammalian intestine.
B. toe of a quadruped. **C.** spine of a cactus.
D. alveolus in a vertebrate lung.
E. piling driven into the earth beneath tall buildings.

Items 212 - 219 deleted.

11. *Photosynthesis*

PHOTOSYNTHESIS

1. (1.10) The process whereby water, carbon dioxide, and light energy are combined through the aid of chlorophyll to produce carbohydrate food is

A. photochemistry. **B.** transpiration.
C. phototropism. **D.** respiration. **E.** photosynthesis.

2. (1.10) Photosynthesis is a chemical process by which plants form

A. starch. **B.** sugar. **C.** sugar from starch.
D. chlorophyll. **E.** starch and chlorophyll.

3. (1.10) Chloroplasts

A. function in photosynthesis.
B. function in respiration. **C.** store food.
D. are located in the nucleus.
E. are found in all plant cells.

4. (1.10) The energy the green plants use in making food usually comes from

A. the soil. **B.** sunlight. **C.** the plant roots.
D. water. **E.** oxygen in the air.

5. (1.10) The rate of photosynthesis may depend on the amount of

A. moisture in the air. **B.** boron in the air.
C. carbon dioxide in the air.
D. carbon dioxide in the soil. **E.** all of these.

True-False

6. (1.10) Chlorophyll is the oxygen-carrying pigment of red blood cells.

7. (1.10) The most useful function of chlorophyll may be that of a(an)

A. pigment.
B. catalyst.
C. excretory product.
D. hormone.
E. reducing agent.

8. (1.10) The bulk of matter in green leaves on a growing plant consists of
A. chlorophyll.
B. starch.
C. water.
D. carbon dioxide.
E. nitrogen.

9. (1.10) All except which one of the following processes contribute carbon dioxide to the atmosphere?
A. Burning of fuels and refuse.
B. Photosynthesis.
C. Volcanic eruptions.
D. Fermentation and decay of dead organisms.
E. Respiration.

10. (1.10) The special function of the green cells of a plant is

A. glucose synthesis.
B. photosynthesis, starch deposition, salt absorption, or protein synthesis, depending on the type of leaf.
C. respiration and transpiration.
D. cellulose formation. **E.** the secretion of auxins.

11. (1.10) The greatest number of green cells are found in higher plants chiefly

A. on the upper surface of leaves.
B. in the epidermis exposed to air.
C. on the lower surface of leaves.
D. along the ribs on leaves.
E. beneath the upper epidermis of leaves.

12. (1.10) As a source of energy in the process of starch synthesis in green plants, which is the least effective portion of the solar spectrum?

A. Green and yellow. **B.** Orange. **C.** Indigo.
D. Red. **E.** Blue and violet.

13. (1.10) Chloroplasts are

A. one of the zones of a leaf.
B. a group of the green algae. **C.** erythrocytes.
D. members of the Protista.
E. formed bodies in plant cytoplasm containing chlorophyll.

14. (1.10) The green pigment, chlorophyll, is found in

A. the vacuole of a leaf cell.
B. the nucleus of a leaf cell.
C. the plastids of leaf cells.
D. the cell sap of leaves.
E. the stomata of leaves.

15. (1.20) An end product of photosynthesis is

A. glucose. **B.** glycogen. **C.** starch.
D. any carbohydrate. **E.** carbon dioxide.

Items 16 - 21 are concerned with photosynthesis. For each item mark

space **A** if the statement is *true* or probably true.
space **B** if the statement is *false* or probably false.
space **C** if there is *insufficient scientific basis* for judging the statement.

16. (1.20) Photosynthetic sugar is used in the synthesis of nearly all other plant products.

17. (3.00) Photosynthetic rate could be increased in a greenhouse experiment by artificially increasing the oxygen supply to the growing plants.

18. (1.20) Both respiration and photosynthesis occur continuously and simultaneously in green plants during the growing season.

19. (1.20) Coal has been derived from transformation of sugar.

20. (1.20) The photosynthetic rate will be higher in a plant exposed to red light than in a plant exposed to a green light during the growth period.

21. (1.20) Photosynthesis is a relatively simple chemical process, understood by most plant chemists.

For items 22 - 24 the key presents brief references to experiments and demonstrations of traditional significance in biological science. By recalling the observations and conclusions of the total experiment choose from the key the laboratory activity that yields the most information in explaining the situations described in items 22 - 24.

KEY

A. The leaves of a certain plant consist of alternate green and white stripes. Some of these leaves were dipped in boiling water, boiled in alcohol, and treated with iodine solution.

B. A plant was kept in a sealed glass bell-jar along with a beaker containing sodium hydroxide.
C. A plant was sealed in a flask with a bell-jar cover. After several hours the walls of the covering jar were observed.
D. The upper surface of one leaf was covered with vaseline, the lower surface of another, and both surfaces of a third were covered. All were on a plant grown in the dark 2 days before the experiment.
E. Corn seedlings grown in sand were carefully removed. All but 2 inches of the root was removed from one and then both placed in a dye solution.

22. (1.20) The manufacturing of food in plants is dependent upon proper functioning of the stomates.

23. (3.00) Farmers notice occasional colorless corn seedlings but never see a mature corn plant that has not developed some color.

24. (1.20) The concentration of carbon dioxide in the air appears to be one factor controlling the rate of plant growth.

25. (1.20) The chemical reactions that are entered into by the elements and compounds which make up living protoplasm always involve

A. catabolic activity. **B.** anabolic activity.
C. energy transformation. **D.** food manufacture.
E. food utilization.

The following key applies to items 26 through 31.

KEY

1. Statement A is greater in quantity or magnitude than Statement B.
2. Statement B is greater in quantity or magnitude than Statement A.
3. Both statements are quantitatively equal.
4. No definite decision can be made from the information given.

	STATEMENT A	STATEMENT B
26. (1.20)	The number of openings on the upper side of the geranium leaf.	The number of openings on the underside of the geranium leaf.
27. (1.20)	The amount of starch present in the leaves of the geranium plant kept in the light for two days, in the absence of carbon dioxide.	The amount of starch present in the leaves of the geranium plant kept in the light for two days, in an excess of carbon dioxide.
28. (1.20)	The amount of time spent by a plant in photosynthetic activity per 24-hour period.	The amount of time spent by a plant in the activities of cellular respiration per 24-hour period.
29. (1.20)	Number of molecules of carbon dioxide used in the production of a molecule of glucose by plants.	Number of molecules of oxygen produced for every molecule of glucose formed by plants.
30. (1.20)	Amount of heat produced by germinating wheat seeds in a day in a closed jar.	Amount of heat produced by dead wheat seeds in a day in a closed jar.
31. (1.20)	Amount of water vapor present in the combustion chamber after the burning of a candle.	Amount of water vapor present in the combustion chamber prior to the burning of a candle.

32. (1.20) The *one* single item of the following list which was *not* used in Engelmann's experiment to demonstrate the site of oxygen production in photosynthesis is

A. algae. **B.** chloroplasts. **C.** mice.
D. bacteria. **E.** microscope.

33. (1.20) Photosynthesis is a unique process in which of the following respects?

A. Carbon dioxide, ordinarily a waste-product, serves a useful function in this process.
B. Water is used as one of the raw materials in the process.
C. A pigment is involved in the process.
D. It is a way by which organic nutrients can be made from inorganic materials.
E. Enzymes play an important role in the process.

34. (1.20) In the process of photosynthesis least light is utilized from which *one* of the following bands of the solar spectrum?

A. Red. **B.** Green. **C.** Indigo blue.
D. Medium blue. **E.** Violet.

35. (1.20) Photosynthesis can best be described as the process in which

A. plants breathe oxygen and discharge carbon dioxide into the atmosphere.
B. nitrogen and carbon dioxide combine by means of light energy to form proteins.
C. water and nitrogen are combined by chlorophyll, using light energy, to form carbohydrates.
D. water and carbon dioxide are combined by means of light energy and chlorophyll to form protein.
E. water and carbon dioxide are combined in the presence of light and under the catalytic action of chlorophyll to form carbohydrates.

Items 36 - 38 consist of entities that are to be compared on the basis of a quantitative relationship. For each item mark space

A. if the quantity in the left hand statement is *greater than* that in the right.
B. if the quantity in the left hand statement is *less than* that in the right.
C. if the quantity in the left hand statement is *the same as* that in the right.

36. (1.20)	The number of stomates on the *upper surface* of a geranium leaf is	**A.** greater than **B.** less than **C.** the same as	the number of stomates on the *lower surface* of a geranium leaf.
37. (1.20)	The amount of energy *stored* by a plant in manufacturing a single molecule of glucose is	**A.** greater than **B.** less than **C.** the same as	the amount of energy *released* by an animal in oxidizing a single glucose molecule.
38. (1.20)	The number of starch molecules *entering* the reaction in which a single starch molecule is digested is	**A.** greater than **B.** less than **C.** the same as	the number of glucose molecules *formed* as a result of the digestion of a single starch molecule.

39. During photosynthesis
(1.20)

- **A.** oxygen and simple sugar combine to form carbon dioxide and water.
- **B.** simple sugar oxidizes and releases energy.
- **C.** water and carbon dioxide combine to form fats and proteins.
- **D.** water and chlorophyll combine to form simple sugar.
- **E.** water and carbon dioxide combine to form simple sugar and oxygen.

Items 40 - 47. (All classified as 1.20)

Read the following paragraph carefully. After the number on the answer sheet which corresponds to that of each sentence, blacken space

- **A.** if the sentence is a description of experimental procedure.
- **B.** if the sentence describes the results of the experiment.
- **C.** if the sentence is a conclusion drawn directly from this particular experiment.
- **D.** if the sentence is a generalization extending the inference drawn from the experimental evidence.
- **E.** if the sentence is none of the above.

(40) "I was able to show by the following experiment that all vegetables are produced immediately and materially from the single element water. **(41)** I took an earthen vessel in which I placed 200 pounds of soil previously dried in an oven. I then watered it with rain water and planted therein a willow branch weighing 5 pounds. **(42)** After an interval of 5 years the tree which had sprung up weighed 169 pounds and some 3 ounces. **(43)** The earthen vessel which was always watered when necessary with rain or distilled water was large and embedded in the ground; lest any flying dust should get mixed with the soil an iron cover plated with tin and provided with a large opening closed the mouth of the vessel. **(44)** I did not determine the weight of the leaves which fell during the four autumns. **(45)** At the end of the experiment I dried the soil again in the vessel and **(46)** obtained the same weight of 200 pounds lacking about 2 ounces. **(47)** The 164 pounds of wood, bark, and roots were therefore derived from water alone." . . . quoted from Jan Baptista van Helmont (1577-1644).

48. The experimenter came to a false conclusion because he
(1.20)

- **A.** used a willow tree rather than a smaller, simpler, plant.
- **B.** failed to collect all of the leaves which fell from the tree in the autumn.
- **C.** failed to consider the air as a source of material for the plant.
- **D.** employed weighing devices which did not allow him the accuracy he needed for his work.
- **E.** failed for a reason other than one of those given in the previous items.

49. The most unique functional feature which distinguishes
(1.20) green plants generally from animals is their

- **A.** mode of respiration.
- **B.** greater extremes in length of life span.
- **C.** mode of reproduction.
- **D.** ability to manufacture food from inorganic raw materials.
- **E.** utilization of small quantities of minerals in metabolism.

On the answer sheet, blacken space corresponding to the letter which designates the *best* completion of the following statements.

50. In photosynthesis
(1.20)

- **A.** glucose is a by-product.
- **B.** starch is a by-product.
- **C.** water is a by-product.
- **D.** oxygen is a by-product.
- **E.** carbon dioxide is a by-product.

51. Photosynthesis is important because it
(1.20)

- **A.** enables green plants to grow.
- **B.** provides all living things with food and oxygen.
- **C.** provides non-green plants with food.
- **D.** provides green plants with food.
- **E.** provides all living things with food.

52. Experiments have shown that
(1.20)

- **A.** plants take in carbon dioxide and give off oxygen in respiration.
- **B.** plants use carbon dioxide during the day but use oxygen at night.
- **C.** green plants can live without oxygen.
- **D.** respiration in plants and animals is alike.
- **E.** plants respire differently from animals.

53. After a green plant has been in the dark for 48 hours,
(1.20) an iodine test shows no starch present in the leaves. This shows that

- **A.** carbon dioxide is necessary for photosynthesis.
- **B.** oxygen is necessary for photosynthesis.
- **C.** light is necessary for photosynthesis.
- **D.** enzymes are necessary for photosynthesis.
- **E.** water is necessary for photosynthesis.

54. Photosynthesis is carried out in the part of the leaf
(1.10) called

A. epidermis. **B.** mesophyll. **C.** vascular bundles.
D. stomates. **E.** intercellular spaces.

55. Water necessary for photosynthesis enters the green
(1.10) plants mainly through

A. the stomates. **B.** the roots. **C.** the root hairs.
D. the xylem. **E.** the root cap.

56. The process by which materials enter and leave the
(1.10) cells of an organism is known as

A. transportation. **B.** transpiration.
C. absorption. **D.** diffusion. **E.** imbibition.

57. Metabolism is
(1.10)

A. energy releasing activities in a cell.
B. reproduction of a cell. **C.** growth of a cell.
D. exchange of materials in a cell.
E. the total of all chemical reactions in a living cell.

58. Protoplasm is a colloidal system in which the dispersed
(1.10) particles are chiefly

A. water molecules. **B.** ions.
C. proteins, fats, carbohydrates, and other organic compounds.
D. proteins only. **E.** none of the above.

59. Which of the following plant responses is associated
(1.20) with the diurnal cycle (day and night)?

- **A.** The potential photosynthetic efficiency is reduced to half of what it might be if the plants grew in continuous light.

B. Starch, accumulated in the leaf cells during the day, is withdrawn and stored at night.
C. The potential starch storage capacity of the roots is only half utilized.
D. Plants attain only a fraction of the size possible in continuous light.
E. The transpiration rate is considerably increased.

60. (1.20) The basic raw materials utilized by green plants in the formation of the complex compounds needed in their own metabolism are

A. glucose and oxygen.
B. oxygen, fats and carbon dioxide.
C. carbohydrates, proteins and fats.
D. carbon dioxide, water and mineral salts.
E. amino acids, carbohydrates and carbon dioxide.

61. (1.20) Which of the following events would limit the process of photosynthesis by reducing the CO_2 content of the atmosphere over the earth's surface?

A. Volcanic eruptions. **B.** Combustion of wood.
C. Respiration of bacteria.
D. Decay of dead organisms. **E.** None of the above.

For items 62 - 66 mark a space on your answer sheet as follows:

Space *1* if true of photosynthesis only.
Space *2* if true of starch synthesis only.
Space *3* if true of all food synthesis.
Space *4* if true of cellular respiration only.
Space *5* if true of more than one of the above, or of none of the above.

62. (1.20) Simple sugar molecules are combined to form large insoluble molecules.

63. (1.20) Oxygen and glucose are raw materials for the reaction.

64. (1.20) Catalytic agents known as enzymes are required for the reaction to proceed.

65. (1.20) Energy from non-living sources is stored in a form that is available to organisms generally.

66. (1.20) The products of the reaction are chemically more complex than the raw materials entering the reaction.

67. (1.20) The chief reason why light is of more immediate and direct importance to plants than to animals is that

A. most plants lack the mobility which is generally characteristic of animals.
B. light is needed to carry on respiration.
C. food in the soil is unavailable to plants without light.
D. light enables plants to utilize moisture from the atmosphere.
E. light is the source of energy in the photosynthetic process.

68. (1.20) The food concentration of a green plant in the evening is

A. greater than **B.** less than **C.** same as
the food concentration of the same green plant in the morning.

69. (1.20) Which one of the following is not necessarily true of the process of photosynthesis?

A. The raw materials used in the process are carbon dioxide and water.
B. The process would ordinarily proceed more rapidly at a temperature of 80°F. than at 40°F.
C. The process occurs only in green leaves.
D. Photosynthesis occurs only in the presence of light.
E. Photosynthesis cannot occur unless chlorophyll is present.

70. (1.20) The part of a plant cell usually believed to be differentially permeable and thus the structure governing the passage of substances into the cell is the

A. middle lamella. **B.** cytoplasmic membrane.
C. nuclear membrane. **D.** cell wall.

71. (1.20) It has been hypothesized that the first living organisms were autotrophs, that is, organisms which can synthesize protoplasm entirely from inorganic matter. Which of the following lines of reasoning is used by some scientists to indicate that this is highly improbable?

A. There is an inverse relationship between simplicity of nutritional requirements and complexity of genetic make-up.
B. There is a direct relationship between simplicity of nutritional requirements and complexity of genetic make-up.
C. There is no relationship between nutritional requirements and genetic make-up.
D. There is no set pattern of relationship between nutritional requirements and genetic make-up.
E. None of the above.

72. (1.20) A leaf from a plant kept in the dark for three days is boiled in alcohol to dissolve out the chlorophyll. When idoine is applied to the leaf, now devoid of chlorophyll

A. the leaf turns brown in color.
B. the leaf turns violet in color.
C. the leaf turns an orange-red color.
D. the leaf becomes green again.

73. (1.20) because

A. the starch has changed to sugar.
B. iodine reverses the chemical reaction and causes chlorophyll to reappear in the leaf.
C. when iodine comes in contact with starch a blue-black color results.
D. no starch is present and the color seen is that of the iodine.

74. (1.20) The number of carbon dioxide molecules used in photosynthesis is

A. greater than **B.** less than **C.** same as
the number of oxygen molecules released by photosynthesis.

75. (1.20) Which of the following reactions takes place only in light?

A. $C_{12}H_{22}O_{11} + H_2O \rightarrow$ 2 molecules of $C_6H_{12}O_6$.
B. $C_6H_{12}O_6 + C_6H_{12}O_6 \rightarrow C_{12}H_{22}O_{11} + H_2O$.
C. $n(C_6H_{12}O_6) \rightarrow n(C_6H_{10}O_5) + n(H_2O)$.
D. $6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$.
E. $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$.

76. (1.20) In starch synthesis

A. sugar, sunlight, and nitrates are necessary.
B. the plant part in which the synthesis occurs must be exposed to light.
C. sugars manufactured in photosynthesis are utilized.
D. no enzymes are necessary.
E. amino acids are eventually produced.

77. Green plants give off carbon dioxide as a result of
(1.20)

A. transpiration. **B.** photosynthesis.
C. respiration. **D.** manufacture of cellulose.

For items 78 - 81 select from the five principles at the right the most closely related principle and blacken the appropriate answer space.

Statements

78. (1.30) Some plants do not possess chlorophyll.

79. (1.30) Photosynthesis is the only process where energy is stored for living organisms.

80. (1.30) The living parts of both plants and animals are constructed of the same basic substance, protoplasm.

81. (1.30) Plants do not have a nervous system.

KEY: *Principles*

A. Motion and locomotion is more restricted in plants than in animals.

B. Some plants are like animals in being dependent on an external source of food.

C. Coordination and integration of action is slower in general in plants than in animals.

D. The vital processes such as digestion, respiration, reproduction and growth are essentially the same in plants and animals.

E. All life would eventually cease if all chlorophyll were destroyed.

After the exercise number on the answer sheet blacken the one lettered space which designates the most similar structure, condition, or process.

82. The role of chlorophyll in photosynthesis:
(2.10)

A. The role of an enzyme in digestion.
B. The role of glucose in respiration.
C. The role of carbon dioxide in respiration.
D. The role of bile in fat digestion.
E. The role of a stimulus in a reflex act.

Items 83 - 91 refer to the chemical and biological relationships which take place inside a sealed aquarium such as the one shown in the diagram.

In this sealed aquarium, circle 1 represents the enclosed air above the water; circle 2, the water; circle 3, the animal life in the water; circle 4, the plant life; and circle 5, the soil at the bottom.

Assume that the proper balance of plant and animal life has been placed in the aquarium before sealing it.

83. It will be possible for life to continue in the aquarium
(2.20)

A. until the original oxygen supply of the air above the water is used up, but not longer.
B. until the original supply of oxygen dissolved in the water has been used up, but not longer.
C. at most, not more than two months.
D. until the original supply of nitrogen in the soil at the bottom is used up, but not longer.
E. indefinitely as long as the sun shines regularly on the aquarium and the temperature stays above freezing.

84. Energy first enters the cycle within the aquarium at
(2.20)

A. 1. **B.** 2. **C.** 3. **D.** 4. **E.** 5.

85. The oxygen supply within the aquarium is replenished at
(2.20)

A. 1. **B.** 2. **C.** 3. **D.** 4. **E.** 5.

86. Carbon dioxide is given off as a waste product at
(2.20)

A. 1. **B.** 1 and 2. **C.** 2 and 5.
D. 1 and 5. **E.** 3 and 4.

87. Carbon dioxide is utilized as a raw material at
(2.20)

A. 1. **B.** 2. **C.** 3. **D.** 4. **E.** 5.

88. Organic nitrogen compounds are given off most profusely and continuously by
(2.20)

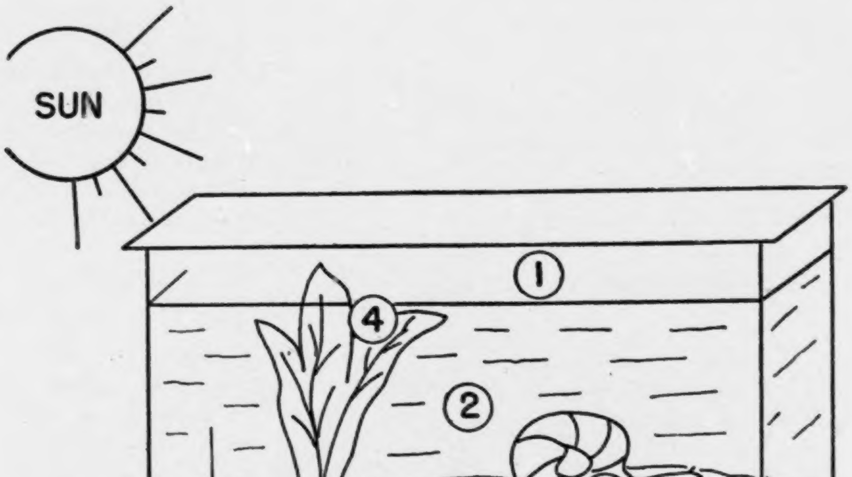
A. 1. **B.** 2. **C.** 3. **D.** 4. **E.** 5.

89. The plants get their nitrogen in nitrate form directly from
(2.20)

A. 1. **B.** 2. **C.** 3. **D.** 4. **E.** None of these.

90. A large source of largely unavailable nitrogen is found at
(2.20)

A. 1. **B.** 2. **C.** 3. **D.** 4. **E.** 5.



91. (2.20) If the aquarium were to be covered with a black cloth for a week the most drastic upset in the balance inside the aquarium would be due to

- **A.** reduced oxygen production.
- **B.** reduced availability of atmospheric nitrogen.
- **C.** reduced amount of organic nitrogen given off.
- **D.** decrease in temperature inside the aquarium.
- **E.** increase in temperature inside the aquarium.

For items 92 - 99 use the following key. Assume all conditions to be normal except the one specifically mentioned in each item.

KEY

- **A.** Photosynthesis is occurring at normal rate; respiration is occurring.
- **B.** Photosythesis is occurring at decreased rate; respiration is occurring.
- **C.** No photosynthesis is occurring but respiration is occurring.
- **D.** Photosynthesis is occurring but no respiration is occurring.
- **E.** Neither photosynthesis nor respiration is occurring.

92. (2.20) In an albino corn plant growing in the light.

93. (2.20) In a leaf of a green plant growing in the light; the lower surface of the leaf is covered with vaseline.

94. (2.20) In a green plant growing in the light in an atmosphere of 5% CO_2.

95. (2.20) In a green plant growing in the light in an atmosphere of .005% CO_2.

96. (2.20) In a green plant in the dark.

97. (2.20) In a green plant on a cloudy day.

98. (2.20) In a green plant in the light in an atmosphere lacking oxygen.

99. (2.20) In a green plant left for 3 days in the dark in an atmosphere lacking in oxygen.

100. (2.20) Which one of the following offers the best evidence that starch formed in leaves does not always remain there?

- **A.** Leaves are green in color while starch is white.
- **B.** Leaves removed from plants at dawn do not turn purple when boiled in alcohol and tested with iodine.
- **C.** Leaves contain an elaborate transport system.
- **D.** Eating spinach leaves is believed to intensify the red color of the blood.
- **E.** Leaves removed from plants in the late afternoon of a bright sunny day become purple after boiling in alcohol and testing with iodine.

101. (2.20) Mark the answer space which corresponds to the letter of the response in the preceding item which would serve as the control in answering the question raised in item 100.

102. (2.20) When a green geranium leaf is tested with iodine, the right half turns yellow while the left half turns blue-black. Which of the following is indicated? (Select the most complete answer.)

- **A.** Half of the leaf probably had no chlorophyll.
- **B.** Half of the leaf had been deprived of atmospheric oxygen.
- **C.** Half of the leaf had been deprived of atmospheric carbon dioxide.
- **D.** More than one of the above is indicated.
- **E.** None of the above is indicated.

103. (2.20) "Experiments have shown that when the sun shines on living leaves, they begin to exhale oxygen and to accumulate carbon and hydrogen—results which are traced to the decomposition by the solar rays, of the carbonic acid and water absorbed." Herbert Spencer, 1881.

In the above passage Spencer is discussing the process we now refer to as

- **A.** phototropism. **B.** assimilation.
- **C.** colloidal dispersion. **D.** photosynthesis.
- **E.** irradiation.

104. (2.20) The rate of photosynthesis in a growing geranium plant would be markedly reduced if for a 24-hour period the plant were to be subjected to any one of four of the following conditions. Which one of the five conditions would *not* produce a marked reduction in photosynthetic rate if the other four factors meanwhile were kept at the optimum?

- **A.** Removal of the soil water.
- **B.** Removal of the atmospheric oxygen.
- **C.** Allow no light to reach the plant.
- **D.** Removal of the atmospheric carbon dioxide.
- **E.** Reduce the temperature to 1° above freezing.

105. (2.20) Which of the following was (were) used in the laboratory as a basis for the inference that "light is necessary for photosynthesis"?

- **A.** A leaf from a healthy plant kept in the dark contained no starch.
- **B.** A leaf from a healthy plant kept in the light contained starch.
- **C.** A leaf from a healthy plant with variegated leaves, which had been kept in the light, contained starch in certain areas and not in others.
- **D.** The information in items **A** and **B** was used.
- **E.** The information in items **A, B,** and **C** was all used.

106. (3.00) Assuming that a single-celled green plant is in a bright light, which of the following best explains the advantage of rapid conversion of the sugar to insoluble starch? *(Assume the cell membrane to be relatively impermeable to sugar.)*

- **A.** Starch can be used more readily by the cell than sugar.
- **B.** The sugar would diffuse out of the cell if it were not converted to starch.
- **C.** The cell would swell and might burst if the sugar were not converted to starch.
- **D.** The starch takes up less room in the cell.
- **E.** None of the above are logical explanations.

107. (3.00) Which of the following offers the best evidence that photosynthesis has occurred?

- **A.** Droplets of water have been deposited on the inner surface of a flask covering a small well-watered geranium plant which has stood for six hours in bright light.
- **B.** A scale from a freshly harvested onion bulb is boiled in a half test tube of water. When the water is later tested with Benedict's solution a yellow precipitate is formed.

C. A leaf from an albino corn plant turns brown when tested with iodine solution.
D. Some green algae plants are put into a beaker of well-aerated tap water. When the Winkler test is applied to a sample of the water an hour later a brown precipitate is formed.
E. A small piece of raw potato is thrust part way down into a test tube containing two milliliters of phenol red, after which the tube is stoppered. The phenol red turns yellow within 15 minutes.

108. (3.00) Assume that you desire to produce a hybrid from two long-day plants whose flowering times are too far apart to allow natural pollination. Assume also that the pollen producing plant is the first to mature. Which one of the following methods would likely be most successful?

A. Give the stigma producing plant a longer day by use of artificial light.
B. Give the pollen producing plant a longer day by use of artificial light.
C. Put the stigma producing plant in a dark room for three or four weeks.
D. Put the pollen producing plant in the dark all day for several weeks.
E. Freeze the pollen when it has matured. Bring it out of cold storage and place it on the stigmas when the female plants are flowering.

109. (3.00) When one molecule of sugar is produced in photosynthesis six molecules of water and six molecules of carbon dioxide are utilized. The molecular weight of water is 18, while the molecular weight of carbon dioxide is 44. On the basis of this information, which one of the following conclusions is most acceptable?

A. The greater bulk (weight) of material which goes to make up the wood in a tree is obtained by the tree from the soil.
B. The greater bulk (weight) of material which goes to make up the wood in a tree is obtained by the tree from the air.
C. Plants absorb nearly all of their food from the soil.
D. Water and carbon dioxide have no relationship to the structure of the wood in a tree.
E. Since plants live under a great variety of environmental conditions no statement can be made as to the relationship between plant structure and source of raw materials.

For the items select from the key the most appropriate phrase.

KEY

A. The statement is *true* according to the graphs.
B. The statement is *false* according to the graphs.
C. The statement *cannot be judged* by the graphs *but* is *in* accord with an established biological principle.
D. The statement *cannot be judged* by the graphs *and* is *not in accord* with an established biological principle.
E. The statement *cannot be judged* by the graphs *or* by an established biological principle.

110. (4.20) If the amount of carbon dioxide is decreased from .123% by volume and the light intensity held constant, there is an increase in carbon dioxide utilization.

111. (4.20) The factor which limits carbon dioxide utilization and thus photosynthesis in Figure 2 is the amount of carbon dioxide present.

112. (4.20) A concentration of 15% carbon dioxide would exert an inhibiting action upon the carbon dioxide utilization and thus upon photosynthesis.

113. (4.20) The carbon dioxide content of the air over a field of wheat (that is, in the stratum of air next to the wheat) on a warm still summer day would be less in daytime than on a still warm night.

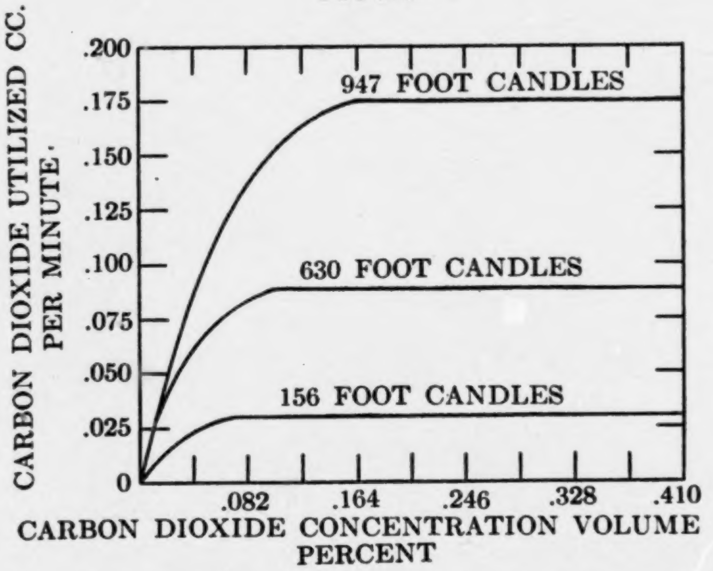
114. (4.20) Within the limit of Graph no. 1 (Figure 1) an increase in concentration of carbon dioxide increases the rate of carbon dioxide utilization, unless some other factor limits the process.

115. (4.20) A factor which limits carbon dioxide utilization and thus photosynthesis cannot be light intensity as long as the light intensity exceeds 150 foot candles.

116. (4.20) With a 1000 foot candle light intensity and a carbon dioxide concentration of .51 volume percent, carbon dioxide utilization cannot exceed .178 cc per minute.

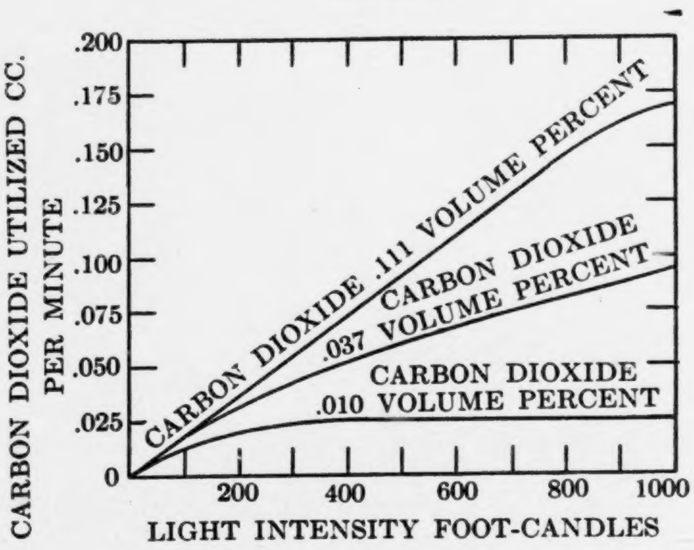
The graphs below are the basis for items 110 - 124.

FIGURE 1



Relation between different carbon dioxide concentrations and rate of photosynthesis in wheat at three different light intensities.

FIGURE 2



Relation between different light intensities and rate of photosynthesis of wheat plants at three different carbon dioxide concentrations.

117. (4.20) With a carbon dioxide concentration of .111% by volume, a doubling in the light intensity in foot candles approximately doubles the carbon dioxide utilization until the doubled value reaches approximately 800 foot candles.

118. (4.20) As far as may be determined from the graphs, the rate of photosynthesis increases with an increase in light, unless some other factor limits the process.

119. (4.20) The carbon dioxide content in the air is approximately .03% by volume. The light intensity at noon on a clear summer day is in the neighborhood of 8000 to 10,000 foot candles. (The two preceding statements are facts.) It is to be expected that the rate of photosynthesis will be limited on a warm summer day by the carbon dioxide content of the air rather than by the lack of sufficient light.

120. (4.20) Water does not influence the rate at which carbon dioxide is utilized per minute.

121. (4.20) With a light intensity of 635 foot candles the rate of photosynthesis increases until between .100 and .125 cc of carbon dioxide are utilized per minute, if a sufficiently high concentration of carbon dioxide is present.

122. (4.20) If the rate of photosynthesis is increased in many crop plants it usually means an increased yield. (The preceding statement is a fact.) A reasonable hypothesis is that a method of supplying more ***carbon dioxide*** to crop plants in the field would raise the yield.

123. (4.20) A wheat plant allowed to germinate in the dark will grow for a time but will not be able to utilize carbon dioxide for food manufacture.

124. (4.20) It may be assumed that a wheat plant would manufacture more food in this latitude growing in a field than on a forest floor, if the conditions of soil, water and carbon dioxide were the same on the forest floor as in the field.

12. Transport, Blood and Circulatory System

TRANSPORT, BLOOD AND CIRCULATORY SYSTEM

1. What is the origin of lymph?
(1.10)

A. It is derived from the blood.
B. It is made by the lymphatic glands.
C. It is secreted by the pancreas.
D. It is produced in the body by the squeezing action of the muscular tissues.
E. It is manufactured in, and secreted by, the spleen.

2. Whole blood cannot be kept more than three weeks in
(1.10) a blood bank. What becomes of over-aged human blood?

A. It is regularly discarded rather than to run the risk of transfusing it into someone's circulatory system by mistake.
B. It is used by medical students in giving experimental transfusions to animals.
C. It is rejuvenated by mixing it in 1 to 1 ratio with fresh blood.
D. It is fractionated, surgical "sponges" being made of the thrombin while other uses are made of the plasma.
E. It is again made usable for transfusions by adding vitamin K to it.

3. Which of the following does not pass freely through the
(1.10) placenta between the mother and the fetus?

A. Oxygen. **B.** Antibodies. **C.** Glucose.
D. Red corpuscles. **E.** Metabolic waste products.

4. In which of the following ways do the auricles (atria) of
(1.10) the heart differ from the ventricles?

A. The auricles are more muscular.
B. The auricles have no valves in their exits.
C. The auricles distribute freshly oxygenated blood only.
D. The auricles have thinner walls than the ventricles.
E. The auricles are not regulated by the sinus node.

5. Hemophilia is an abnormal condition
(1.10)

A. caused by lack of vitamin A.
B. characterized by dizziness brought about through the inability of the blood to carry sufficient oxygen to the brain.
C. caused by lack of vitamin C.
D. characterized by profuse bleeding from slight wounds.
E. caused by the bite of the anopheles mosquito.

6. The blood is aerated in the
(1.10)

A. systemic system. **B.** pulmonary system.
C. lymphatic system. **D.** hepatic portal system.
E. autonomic system.

7. Whole blood consists of
(1.10)

A. serum and corpuscles. **B.** fibrin and corpuscles.
C. plasma and corpuscles. **D.** plasma and platelets.
E. serum and platelets.

8. The tricuspid valve lies
(1.10)

A. between the right and left auricles.
B. between the right and left ventricles.
C. between the left auricle and the left ventricle.
D. between the right auricle and the right ventricle.
E. at the opening where the aorta leads out of the heart.

9. Blood plasma which has had the fibrinogen removed is
(1.10) known as

A. blood concentrate. **B.** serum.
C. the hormone complement.
D. the antibody component.
E. the cellular complement.

10. Which one of the following is considered to be a blood
(1.10) protein?

A. Digested and absorbed egg white.
B. Glycogen. **C.** Fibrinogen.
D. Calcium chloride. **E.** Sodium bicarbonate.

11. Which one of the following is present in the walls of
(1.10) both capillaries and arteries?

A. Connective tissue. **B.** Muscle tissue.
C. Endothelial tissue. **D.** Adipose tissue.
E. Cartilaginous tissue.

12. The bulk of the heart is composed of
(1.10)

A. epithelial tissue. **B.** smooth muscle tissue.
C. cardiac muscle tissue. **D.** connective tissue.
E. nodal tissue.

13. Which of the following best describes whole blood?
(1.10)

A. It consists of serum and red corpuscles.
B. It consists of plasma and platelets.
C. It consists of serum and platelets.
D. It consists of fibrin and corpuscles.
E. It consists of plasma and corpuscles.

14. It is believed that those suffering from the hereditary
(1.10) disease in which the blood is slow to clot have such a condition because

A. their platelets are not sufficiently fragile.
B. they lack vitamin K.
C. they lack sufficient calcium in the blood.
D. they lack prothrombin. **E.** they lack fibrinogen.

15. A blood clot is formed primarily from fibrin and
(1.10)

A. thrombin. **B.** calcium. **C.** plasma.
D. red corpuscles. **E.** fibrinogen.

16. The sinus node in man
(1.10)

A. is the initiator of the heart beat.
B. serves as a receptacle for blood entering the heart.
C. is a long narrow cavity in the head through which pus discharges.
D. is a nerve center in the head whose stimulation is a frequent cause of headache.
E. is a valve between the atrium and ventricle which prevents the blood from reversing its course in the circulatory system.

17. A "cold-blooded" animal is characterized by
(1.10)

A. maintaining a body temperature several degrees lower than its environment.
B. maintaining a body temperature lower than that of man.
C. allowing body temperature to fluctuate with environmental temperatures.

D. requiring a higher temperature than necessary for comfort of other closely related animal forms.
E. habitually sluggish behavior on warm days.

18. The capillaries
(1.10)

A. only carry blood free of all carbon dioxide.
B. only carry blood free of all oxygen.
C. connect arteries and veins.
D. are tiny arteries. **E.** are tiny veins.

19. Oxygen is carried in the blood by the
(1.10)

A. lymph. **B.** erythrocytes. **C.** fibrin.
D. phagocytes. **E.** platelets.

20. The bulk of material comprising blood plasma is probably
(1.10)

A. hemoglobin. **B.** fibrinogen.
C. the antibody complement. **D.** water.
E. the hormone complement.

21. The fundamental mechanism of transport found in all organisms, both plant and animal, is
(1.10)

A. osmosis. **B.** a vascular system.
C. gravitational circulation. **D.** diffusion.
E. forced circulation.

22. Gases diffuse into and out of the blood
(1.10)

A. in the arteries. **B.** in the veins.
C. in the heart. **D.** in the lymphatics.
E. in the capillaries.

23. Hemoglobin is most closely associated with
(1.10)

A. blood clotting. **B.** hormone formation.
C. oxygen transport. **D.** food transport.
E. lymph transport.

24. A capillary bed is a network of minute blood vessels in which
(1.10)

A. the red corpuscles leave the circulatory system to re-enter the system later.
B. the red corpuscles stop flowing altogether like a train which stops at a station to load and unload cargo.
C. the red corpuscles make a complete oxygen-carbon dioxide exchange each time they go around the circuit.
D. more than one of the above regularly occur.
E. none of the above regularly occurs.

25. Vasoconstriction means
(1.10)

A. contraction of arteries. **B.** dilation of arteries.
C. contraction of veins. **D.** dilation of veins.
E. contraction of capillaries.

26. The vitamin necessary for normal clotting of the blood is
(1.10)

1. A. **2.** B. **3.** C. **4.** E. **5.** K.

27. Certain foreign proteins introduced in the blood stream of the body are called
(1.10)

A. antigens. **B.** antibodies. **C.** antitoxins.
D. antimeres. **E.** agglutinins.

28. Lymph nodes serve to prevent bacteria from
(1.10)

A. entering cut tissues. **B.** entering the blood.
C. killing white blood cells. **D.** clotting the blood.
E. generating a high osmotic pressure in tissue fluid.

29. A human white blood corpuscle
(1.10)

A. contains oxyhemoglobin.
B. has no nucleus. **C.** is formed in the liver.
D. is larger than a human red blood cell.

30. Indicate the best response with respect to the functioning of the lymphatic system.
(1.10)

A. It provides a moist environment about the cells of the body.
B. It aids in disease prevention.
C. It transports fats.
D. It facilitates diffusion of various substances to and from the cells of the body.
E. More than one of the above.

Items 31 - 32 have been deleted.

33. What is the function of blood platelets?
(1.10)

A. Aid in the coagulation of blood.
B. Carry hemoglobin. **C.** Ingest bacteria.
D. Transport carbon dioxide.

34. Blushing involves dilation of some of the
(1.10)

A. arteries. **B.** arterioles. **C.** veins.
D. capillaries. **E.** lymphatics.

35. In arterial blood, most of the oxygen which is available to tissues is carried
(1.10)

A. dissolved in the plasma.
B. dissolved in red blood cells.
C. in loose chemical combination with bicarbonate ion.
D. in loose chemical combination with an organic pigment.
E. as water.

36. The span of life of red corpuscles is
(1.10)

A. 10-30 days. **B.** 4-6 months. **C.** about 24 hours.
D. the life-time of the person.
E. impossible to calculate or estimate.

37. Clotting of newly drawn blood would be prevented by the addition of
(1.10)

A. prothrombin. **B.** heparin. **C.** fibrinogen.
D. none of the above.

38. Which of the following leucocytes are most numerous in the blood of a normal man?
(1.10)

A. lymphocytes. **B.** eosinophils. **C.** basophils.
D. nutrophils.

39. Arteries may be defined as vessels carrying
(1.10)

A. "impure" blood. **B.** blood away from the heart.
C. "pure" blood. **D.** blood toward the heart.

40. Which of the following are not present in the lymphatic system?
(1.10)

A. white blood cells. **B.** food materials.
C. red blood cells. **D.** valves.

41. Conservation of heat by the body is aided by
(1.10)

A. dilation of capillaries of skin.
B. constriction of capillaries of skin.
C. increased sweat production.
D. increased respiratory activity.

42. Most of the oxygen is carried
(1.10)

A. in the lymph. B. in the red blood cells.
C. in the blood plasma.
D. in the white blood cells (leucocytes)

43. Food materials carried in the blood include
(1.10)

A. Amino acids. B. disaccharides. C. urea.
D. carbon dioxide.

44. Hemoglobin is found in
(1.10)

A. blood plasma. B. red blood corpuscles.
C. white blood corpuscles. D. blood platelets.

45. A portal vein carries blood
(1.10)

A. to capillaries. B. from capillaries.
C. from capillaries to capillaries.
D. from liver to intestine.

46. Most of the carbon dioxide which enters the blood
(1.10) from the tissues is carried

A. as such, dissolved in the plasma.
B. as such, dissolved in red blood cells.
C. as bicarbonate ion dissolved in both plasma and red blood cells.
D. in loose chemical combination with an organic pigment.
E. as organic compounds belonging to the Krebs cycle.

47. Oxyhemoglobin has which of the following character-
(1.10) istics?

A. It separates very readily into oxygen and hemoglobin.
B. It has a deep purplish murky color.
C. It is a highly explosive substance.
D. It is a highly stable compound which changes its character only in the presence of a strong reagent.
E. None of the above.

48. The known function of blood platelets is to
(1.10)

A. engulf bacteria. B. secrete antibodies.
C. initiate clotting. D. carry carbon dioxide.
E. carry fat globules.

49. Four of the following are found in the blood plasma.
(1.10) Which one is *not* found in the plasma but is a component of the cellular portion of the blood?

A. Fibrinogen. B. Adrenalin being transported.
C. The anti-A antibody.
D. Nitrogenous waste in transport. E. Hemoglobin.

50. Capillaries are absent from
(1.10)

A. earthworms (Annelida).
B. marine worms (Annelida).
C. proboscis worms (Nemertea).
D. amphioxus (Chordata). E. lamprey (Chordata).

51. Which of the following functions is (are) performed
(1.10) by the lymph glands?

A. They produce white blood cells which destroy bacteria.
B. They produce red corpuscles.
C They manufacture digestive enzymes.
D. They manufacture lymph.
E. They manufacture plasma proteins.

52. A blood clot is formed from fibrin and
(1.10)

A. thrombin. B. calcium. C. plasma.
D. red corpuscles. E. fibrinogen.

53. When both atria and ventricles are completely relaxed
(1.10) from the heart contraction which has just been completed, the next contraction is initiated by

A. an impulse from the atrio-ventricular bundle.
B. an impulse from the sinus node.
C. flexing of the muscles of the atria.
D. opening of the aortic valve.
E. flexing of the muscles of the ventricles.

For items 54 - 62 select from the key lists below the choice which is the best fill-in for each of the numbered blanks in the following paragraphs. Use Key List 1 for answers in the first paragraph and Key List 2 for answers in the second paragraph.

KEY LIST 1

A. fibrin B. blood proteins C. plasma
D. serum E. red blood cells

When a child steps on a rusty nail, the flow of blood gradually stops as a clot forms at the site of the injury. The basic clot material is 54.________, which is composed of fine strands in which 55.________become entangled to make a dam against the further loss of blood. The basic material referred to does not occur as such in normal circulating blood, but its precursor is one of the normal 56.________contained in the 57.________, or fluid part of the blood. When this is removed, the remaining fluid, now known as 58.________, may ooze for a time through the developing clot.

(All of the above items are classified as 1.20)

KEY LIST 2

A. platelets B. antibodies C. white blood cells
D. antigens E. antitoxins

Bacteria, particularly in puncture wounds, are usually carried in to the underlying tissues, where they may be very difficult to reach by means of disinfectants. The blood, however, contains a particular kind of cell which can attack these invaders and actually engulf them. These cells are known as 59.________. If the bacteria are a kind with which the body has had some previous experience, their destruction may be aided by chemical substances in the blood known as 60.________. Such substances are highly specific in their action, each one being effective only against the 61.________that first induced its formation in the blood and body tissues. Some of them, known as 62.________, do not act at all against bacteria, but only neutralize the poisons that they may produce.

(Items 59, 60, 62 are classified as 1.10; item 61 as 1.20)

For items 63 - 80, after each exercise number on the answer sheet, blacken the *one* lettered space which designates the correct answer.

63. (1.10) The human heart is inclosed in a membranous sac called the

A. peritoneum. **B.** pleural sac. **C.** periosteum.
D. pericardium.

64. (1.10) The upper chambers of the human heart are called

A. venae cavae. **B.** ventricles. **C.** auricles.
D. pleurae.

65. (1.20) A strong vertical septum separates the right ventricle from the

A. right auricle. **B.** aorta. **C.** left ventricle.
D. tricuspid valve. **E.** semilunar valves.

66. (1.10) Blood vessels that carry blood to the heart for recirculation are called

A. veins. **B.** capillaries. **C.** arteries.
D. lymphatics. **E.** arterioles.

67. (1.20) The lymph of the human body is finally collected into two large vessels which open into

A. arteries. **B.** veins. **C.** capillaries.
D. portals. **E.** the aorta.

68. (1.20) Blood returning to the human heart from the lungs for recirculation first enters the

A. left auricle. **B.** right auricle.
C. right ventricle. **D.** left ventricle.

69. (1.10) Blood leaves the left ventricle by way of the blood vessel called the

A. pulmonary artery. **B.** pulmonary vein.
C. aorta. **D.** vena cava.

70. (1.20) Portal circulation includes the portion of the systemic circulation that courses from the digestive regions to the liver and then to the

A. spleen. **B.** heart. **C.** lungs. **D.** stomach.

71. (1.20) In the human heart, the chamber with the thickest walls is the

A. left ventricle. **B.** right ventricle.
C. left auricle. **D.** right auricle.

72. (1.20) Blood returns from the lungs to the

A. left ventricle. **B.** right auricle.
C. left auricle. **D.** right ventricle.

73. (1.20) The blood vessels equipped with the most valves are the

A. arteries. **B.** veins. **C.** capillaries.
D. arterioles. **E.** venules.

74. (1.10) Failure of the blood to clot properly is responsible for the condition called

A. arteriosclerosis. **B.** angina pectoris.
C. hemophilia. **D.** hematoma.
E. coronary thrombosis.

75. (1.20) At the base of each main artery leaving the heart are the

A. bicuspid valves. **B.** mitral valves.
C. tricuspid valves. **D.** semilunar valves.
E. auriculo-ventricular valves.

76. (1.10) A clot which remains attached to its point of origin and obstructs blood flow is called

A. embolus. **B.** thrombus. **C.** fibrin.
D. thrombin. **E.** anastomoses.

77. (1.20) An artery that carries blood with a low concentration of oxygen is the

A. femoral artery. **B.** coronary artery. **C.** aorta.
D. pulmonary artery. **E.** carotid artery.

78. (1.20) A vein that carries blood with a high concentration of oxygen is the

A. pulmonary vein. **B.** subclavian vein.
C. hepatic vein. **D.** vena cava. **E.** renal vein.

79. (1.10) The liquid formed when blood clots is called

A. plasma. **B.** lymph. **C.** serum.
D. whole blood. **E.** water.

80. (1.10) The impulse for each heartbeat originates in a group of cells located in the wall of the right auricle. This group of cells is called the

A. right atrium. **B.** sinus node.
C. atrio-ventricular tissue. **D.** cardiac muscle.

81. (1.10) Coronary thrombosis is due to

A. the presence of a leaky valve in the heart.
B. stoppage of one of the small arteries on the surface of the heart.
C. a cramping of the heart muscle.

82. (1.20) Which of the following circulatory patterns best characterizes insects?

A. Blood and undifferentiated blood vessels.
B. Arteries, blood, heart, and tissue spaces.
C. Arteries, blood, capillaries, heart and veins.
D. Blood, capillaries, veins, and pulsatile arteries.
E. Arteries, blood, capillaries, veins and multiple hearts.

83. (1.20) The number of neutrophils in human blood is

A. greater than **B.** less than
C. same as the number of lymphocytes in human blood.

84. (1.20) In general, the rate of flow of blood in a vein is

A. less rapid than in its capillary bed.
B. more rapid than in the artery which drains into its capillary bed.
C. negatively correlated with diameter (i.e., slower in the larger veins).
D. negatively correlated with the diameter of the corresponding artery.
E. more rapid than in its capillary bed.

85. (1.20) The length of life of an erythrocyte in the circulation of man is

A. greater than **B.** less than
C. same as the length of life of a leucocyte in the circulation.

86. (1.20) The acceleration of clotting of newly drawn blood by the addition of fibrinogen is

A. greater than **B.** less than
C. same as the acceleration of clotting by the addition of thrombin.

87. Diastolic blood pressure is
(1.20)

A. greater than **B.** less than
C. same as systolic blood pressure.

88. In man the volume of blood pumped by the right ventricle is
(1.20)

A. greater than **B.** less than
C. same as the volume of blood pumped by the left auricle.

For items 89 - 100, after each exercise number on the answer sheet, blacken the *one* lettered space which designates the correct answer.

Imagine a small volume of blood in the *right auricle* of the human heart.

89. This chamber contracts and the blood is forced through the
(1.20)

A. pulmonary valve. **B.** aortic valve.
C. tricuspid valve. **D.** mitral or bicuspid valve.

90. After passing through the above valve, the blood enters the
(1.20)

A. right auricle. **B.** left auricle.
C. right ventricle. **D.** left ventricle.

91. This chamber then contracts and the blood is forced through the
(1.20)

A. pulmonary valve. **B.** aortic valve.
C. tricuspid valve. **D.** mitral or bicuspid valve.

92. Then the blood passes into the vessel termed the
(1.20)

A. pulmonary vein. **B.** pulmonary artery.
C. aorta. **D.** vena cava.

93. This blood vessel conducts the blood to the capillaries of the
(1.20)

A. heart. **B.** liver. **C.** lung. **D.** kidney.
E. spleen.

94. The blood then leaves this organ via the
(1.20)

A. pulmonary vein. **B.** pulmonary artery.
C. aorta. **D.** vena cava. **E.** portal vein.

95. From this vessel the blood next enters the
(1.20)

A. right auricle of the heart.
B. left auricle of the heart.
C. right ventricle of the heart.
D. left ventricle of the heart.

96. This chamber contracts and the blood is forced through the
(1.20)

A. pulmonary valve. **B.** aortic valve.
C. tricuspid valve. **D.** mitral or bicuspid valve.

97. After passing through the valve just mentioned, the blood enters the
(1.20)

A. right auricle. **B.** left auricle.
C. right ventricle. **D.** left ventricle.

98. This chamber contracts and the blood is forced through the
(1.20)

A. pulmonary valve. **B.** aortic valve.
C. tricuspid valve. **D.** mitral valve.

99. The blood next enters the
(1.20)

A. pulmonary vein. **B.** pulmonary artery.
C. aorta. **D.** vena cava.

100. The blood then travels through the general circulation of the body and eventually returns to the heart via one of the
(1.20)

A. pulmonary veins. **B.** pulmonary arteries.
C. aortae. **D.** venae cavae.

101. The number of red blood cells per unit volume entering the bone marrow is
(1.20)

A. greater than **B.** less than
C. same as the number of red blood cells per unit volume leaving the bone marrow.

102. The relative number of white cells present in the blood from time to time may depend upon
(1.20)

A. the presence or absence of infective agents in the body.
B. the altitude at which the individual lives.
C. the amount of iron in the individual's diet.
D. the sex of the individual—whether male or female.
E. none of the above factors.

103. White blood cells differ from red corpuscles in four of the following respects. In which respect are they alike?
(1.20)

A. They are self-propelling.
B. They lack hemoglobin.
C. They circulate in the plasma.
D. They have definite organized nuclei.
E. Their primary function is to combat infection.

104. Which of the following structures is (are) found in veins but not in arteries?
(1.20)

A. Muscles. **B.** Valves. **C.** Connective tissue.
D. Endothelial cells. **E.** Interior cavity.

105. Exchange of substances between the blood and the body cells takes place through the environment common to both, which is the
(1.20)

A. cell wall. **B.** endothelial layer.
C. tissue fluid. **D.** blood plasma.
E. connective tissue layer.

106. Simple elevation of arteriolar blood pressure results in
(1.20)

A. decreased diffusion of materials from blood to tissues.
B. increased time required for blood to traverse capillaries.
C. increase in the differences in concentration of materials in solution in blood and tissue fluids.
D. increased local vasoconstriction.
E. increased lymph production.

107. Select the one function which is not true of the circulatory system of an adult human.
(1.20)

A. Transportation of wastes. **B.** Distribution of heat.
C. Protection against disease.
D. Formation of hormones.
E. Formation of lymphocytes.

108. The blood of man differs from insects in that it carries
(1.20)

A. oxygen to the cells. **B.** wastes from the tissues.

C. sugars to the tissues. **D.** salts in solution.
E. water.

109. (1.20) Blood pressure in capillaries is

A. greater than **B.** less than
C. same as the blood pressure in the veins.

110. (1.20) The number of red blood cells per unit volume in the blood of men living in the mountains is

A. greater than **B.** less than
C. same as the number of red blood cells per unit volume in the blood of men living in the lowlands.

111. (1.20) The elasticity of the arterial walls of an old individual is

A. greater than **B.** less than
C. same as the elasticity of the arterial walls of a young individual.

112. (1.20) An immediate effect of severe hemorrhage is

A. an increase in the rate of arterial blood flow.
B. a decrease in arterial blood pressure.
C. an increase in arterial blood pressure.
D. a change in the proportion of antibodies in the blood.
E. a change in the proportion of salts in the blood.

113. (1.20) Which one of the following blood transfusions must never be made under any circumstances?

A. A donor to AB recipient.
B. A donor to B recipient.
C. O donor to A recipient.
D. B donor to AB recipient.
E. O donor to AB recipient.

114. (1.20) Of the following blood transfusions, which is the only one that could safely be made?

A. A donor to B recipient.
B. AB donor to A recipient.
C. B donor to O recipient.
D. O donor to A recipient.
E. AB donor to B recipient.

115. (1.20) The water lost from blood to the lymph

A. is regained when the lymph empties into the blood.
B. is replaced by the water absorbed from the digestive tract.
C. is replaced by the water produced by cellular respiration.
D. necessitates the 99% conservation of water in the kidneys.
E. is conserved since it cannot be lost via the sweat or the lungs.

116. (1.20) The blood clotting time before an operation for removal of the liver is

A. greater than **B.** less than
C. same as the blood clotting time after the operation.

For items 117 - 139, after the number on the answer sheet which corresponds to that of each of the following paired items, blacken space

A. if the item in Column 1 is greater than that in Column 2.
B. if the item in Column 2 is greater than that in Column 1.
C. if the two items are of essentially the same magnitude.

	Column 1		*Column 2*
117. (1.20)	The importance of the xylem tissue as a food transporting system in higher plants.	....	The importance of the phloem tissue as a food transporting system in higher plants.
118. (1.20)	The thickness of the wall of an artery.	....	The thickness of the wall of the corresponding vein.
119. (1.20)	The number of chambers in the heart of a perch.	....	The number of chambers in the heart of a frog.
120. (1.20)	The probability that a severe hemorrhage will affect the red blood cell count.	....	The probability that destruction of bone marrow will affect the red blood cell count.
121. (1.20)	The number of red blood cells per cubic mm. of blood.	....	The number of white blood cells per cubic mm. of blood.
122. (1.20)	The number of white blood cells per cubic mm. of blood of a normal healthy individual.	....	The number of white blood cells per cubic mm. of blood of an individual with acute appendicitis.
123. (1.20)	The amount of iron salvaged by the human body from the destruction of the red blood cells.	....	The amount of iron eliminated by the human body from the destruction of red blood cells.
124. (1.20)	The number of thrombocytes per cubic mm. of blood.	....	The number of white blood cells per cubic mm. of blood.
125. (1.20)	Volume of blood entering the right auricle.	....	Volume of blood entering the right ventricle.
126. (1.20)	The likelihood that the heart tissues obtain food, oxygen, etc., from the blood contained in the chambers.	....	The likelihood that the heart tissues obtain food, oxygen, etc., from the blood supplied to it through separate vessels.
127. (1.20)	The clotting time of hemophiliac individuals.	....	The clotting time of non-hemophiliacs.
128. (1.20)	The number of valves in arteries.	....	The number of valves in veins.
129. (1.20)	The amount of oxygen per cc. of the blood in the pulmonary arteries.	....	The amount of oxygen per cc. of blood in the pulmonary veins.
130. (1.20)	The amount of oxygen per cc. in the blood in the venae cavae.	....	The amount of oxygen per cc. in the blood in the aorta.
131. (1.20)	The thickness of the wall of the human right ventricle.	....	The thickness of the wall of the human left ventricle.
132. (1.20)	The probability that an increase in carbon dioxide in the blood will affect the rate of the heart beat.	....	The probability that an increase of adrenalin in the blood will affect the rate of the heart beat.

133. (1.20) The rate of flow of blood in arteries. .... The rate of flow of blood in the capillaries.

134. (1.20) The volume of blood passing through the venae cavae. .... The volume of blood entering the right auricle.

135. (1.20) The rate of flow of blood in a vein. .... The rate of flow of blood in the corresponding artery.

136. (1.20) Arterial blood pressure before stimulation of the vagus nerve. .... Arterial blood pressure after stimulation of the vagus nerve.

137. (1.20) Systolic blood pressure. .... Diastolic blood pressure.

138. (1.20) Arterial blood pressure in an infant. .... Arterial blood pressure in an adult.

139. (1.20) The pressure of blood in the venae cavae. .... The pressure of blood in the aorta.

140. (1.20) The number of red blood cells stored for emergency used by the bone marrow is

A. greater than **B.** less than
C. same as the number stored for emergency use by the spleen.

141. (1.20) The amount of iron lost by the body when a large number of red blood cells are lost by hemorrhage is

A. greater than **B.** less than
C. same as the amount of iron lost by the body through normal mode of destruction of the same number of red blood cells.

142. (1.20) The number of leucocytes in the blood of a person who has been cured of an infection such as appendicitis is

A. greater than **B.** less than
C. same as the number of leucocytes in the blood before treatment.

143. (1.20) Normal operation of the valves in the heart is most dependent upon

A. contraction of attached tendons.
B. contraction of muscles in the valve flaps.
C. back pressure of the blood.
D. contraction of the sphincter muscles in the heart.
E. properties peculiar to cardiac tissue.

144. (1.20) The structure of capillaries, when compared with arteries, reveals

A. no differences.
B. the lack of endothelium, muscle, and connective tissue in capillaries.
C. a larger number of valves in the capillaries.
D. only one kind of tissue common to both.
E. the capillaries to be microscopic arteries.

145. (1.20) The circulation of the lymph differs from the circulation of the blood in man in that

A. the lymph vessels do not form a continuous system.
B. the motion of the lymph is derived from contraction of the nodes rather than a central heart.
C. no provision is made for destruction of harmful bacteria.
D. the lymph vessels are not branched.
E. none of the above; there are no differences.

146. (1.20) The average number of red blood cells per unit volume in human females is

A. greater than **B.** less than
C. same as the average number per unit volume in males.

147. (1.20) The entire capillary wall is equivalent to which of the following parts of an artery?

A. Endothelium. **B.** Smooth muscle.
C. Connective tissue. **D.** Lumen.
E. Elastic connective tissue.

148. (1.20) The usual path traversed by a drop of blood in passing from the region of the knee in man to the heart, thence to the lung is

A. capillary, small vein, iliac vein, vena cava, left ventricle, left auricle, pulmonary artery, capillary in lung.
B. capillary, small vein, vena cava, iliac vein, left auricle, left ventricle, pulmonary artery, capillary in lung.
C. capillary, small vein, iliac vein, vena cava, left auricle, left ventricle, pulmonary vein, capillary in lung.
D. capillary, small vein, iliac vein, vena cava, right auricle, right ventricle, pulmonary artery, capillary in lung.
E. capillary, small vein, iliac vein, vena cava, right auricle, right ventricle, pulmonary vein, capillary in lung.

149. Blood clotting occurs as a consequence of the following steps:

1. hemorrhage → release of thromboplastin (thrombokinase)
2. calcium and thromboplastin and prothrombin → thrombin
3. thrombin and fibrinogen → fibrin

The blood platelets play a role in

A. step 1. **B.** step 2. **C.** step 3.
D. steps 2 and 3. **E.** none of the above steps.

150. (1.20) Simple elevation of arteriolar blood pressure results in

A. decreased diffusion of materials from blood to tissues.
B. increased time required for blood to traverse capillaries.
C. increase in the differences in concentration of materials in solution in blood and tissue fluids.
D. increased local vasoconstriction.
E. increased lymph production.

151. (1.20) Red blood cells swell in a certain salt solution; this means that the concentration of the salt solution is

A. greater than **B.** less than
C. same as the concentration of the blood plasm.

152. (1.20) The concentration of simple iron compounds in the blood entering the bone marrow is

A. greater than **B.** less than
C. same as the concentration of simple iron compounds in the blood leaving the bone marrow.

153. (1.20) The velocity of flow of blood in veins is

A. greater than **B.** less than
C. same as the velocity in the capillaries.

154. The speed with which blood passes through a capillary is
(1.20)

A. greater than its speed in the corresponding venule, but less than its speed in the corresponding arteriole.
B. greater than its speed in the corresponding arteriole, but less than its speed in the corresponding venule.
C. greater than its speed in both the corresponding arteriole and venule.
D. less than its speed in both the corresponding arteriole and venule.
E. the same as its speed in both the corresponding arteriole and venule.

155. The vein whose blood has the lowest concentration of
(1.20) urea is

A. the inferior vena cava. **B.** the hepatic vein.
C. the pulmonary vein. **D.** the renal vein.
E. the hepatic portal vein.

156. All *except* which one of the following factors may affect
(1.20) blood clotting time?

A. Temperature. **B.** Vitamin K.
C. White corpuscle count. **D.** Condition of the liver.
E. Blood platelet count.

157. Heat produced in the human body is distributed by the
(1.20) blood. One of the major factors in maintaining the body temperature at a constant level is

A. reducing or increasing the size of the blood vessels near the body surface.
B. decreasing or increasing the size of the aorta.
C. inhibiting nerve impulses to the heat and cold receptors.
D. increasing or decreasing the amount of food eaten.
E. endocrine secretion.

158. The direction of movement of glucose in tissue fluid is
(1.20) determined by

A. gravity. **B.** relative temperatures.
C. relative concentrations.
D. proximity to nerve cells. **E.** size of blood vessels.

159. The chief method of transport of substances within the
(1.20) cytoplasm of the ameba is

A. circulation of materials in the blood stream.
B. circulation in response to gravity.
C. circulation in response to body movements.
D. diffusion in response to molecular motion.
E. osmosis in response to inequalities in osmotic pressure.

160. The wall of the aorta is thicker than the wall of any
(1.20) other blood vessel in the body. This greater thickness is most closely correlated with the

A. pressure of the blood in the first part of the systemic circuit.
B. pressure of the blood in the last part of the pulmonary circuit.
C. osmotic exchange through the wall of the aorta.
D. relatively high oxygen concentration of the blood in the aorta.
E. force of gravity acting upon the blood in this part of the circulatory system.

161. The vein whose blood has exactly the same composition
(1.20) as that in the aorta is

A. the superior vena cava. **B.** the inferior vena cava.
C. the hepatic vein. **D.** the coronary vein.
E. the pulmonary vein.

162. Lymph capillaries differ from blood capillaries in that
(1.20) lymph capillaries

A. are "blind alley" types of vessels.
B. have much thinner walls than blood capillaries.
C. are "flow-through" types of vessels.
D. carry only freshly oxygenated blood.
E. are reserve types of vessels which function only on an emergency basis at irregular intervals.

163. When lymph circulation and venous blood circulation
(1.20) are compared they are found to be similar in that

A. circulating fluids in both contain cells.
B. both contain fluids colored red by the hemoglobin content.
C. blood emerging from a cut (severed) vessel in either system would show a pulse.
D. rate of circulation in both systems may be increased by muscle contractions in the organs through which the vessels pass.
E. fluids of both systems contain no cells.

164. Blood entering the heart from the posterior vena cava
(1.20) has most recently been in the

A. finger tips. **B.** brain. **C.** lower abdomen.
D. lungs. **E.** left ventricle.

165. What causes oxygen to enter the capillaries at some
(1.20) points in the body and to leave the capillaries at different points in the body?

A. Oxygen is discharged where it is needed by the cells —the existence of the need determines whether it will be discharged or not.
B. Oxygen diffuses from a region of lesser concentration to a region of greater concentration.
C. Oxygen must be exchanged for carbon dioxide.
D. Oxygen diffuses from a region of greater concentration of oxygen to a region of lesser concentration of oxygen.
E. Oxygen will be discharged only where there is food to be oxidized.

166. The fundamental mechanism of transport found in all
(1.20) organisms, both plant and animal, is

A. osmosis. **B.** a vascular system.
C. gravitational circulation. **D.** diffusion.
E. forced circulation.

Items 167 - 171 are based on the following key list.

KEY

A. hepatic portal system **B.** lymphatic system
C. superior vena cava **D.** dorsal aorta
E. pulmonary vein

167. Which carries a mixture of amino acids, water, salts,
(1.20) and glucose, etc., but no blood cells?

168. Which carries dissolved food materials to the liver?
(1.20)

169. Which carries blood down from the heart to supply the
(1.20) various tissues and organs of the body?

170. Which has the highest concentration of freshly-oxygen-
(1.20) ated blood?

171. Which has the lowest blood pressure?
(1.20)

172. (1.20) Which of the following is unique about capillaries as a kind of blood vessel?

- **A.** The blood usually flows through them in one direction.
- **B.** A capillary has a lumen or internal cavity.
- **C.** The formed elements of the blood are here carried in the plasma.
- **D.** Capillaries have an endothelium.
- **E.** Diffusion of substances into and out of these vessels is possible.

173. (1.20) Failure of the blood to clot readily when exposed to air may be due to

- **A.** an oversupply of erythrocytes.
- **B.** a deficiency of leucocytes.
- **C.** a superabundance of fibrin.
- **D.** the presence of an embolus.
- **D.** an inadequacy of thrombokinase.

Below are given a number of statements made by René Descartes (1596 - 1650) dealing with circulation. The numbers in the blanks refer to the numbers on the answer sheet. If the term to fill in the blank refers to a blood vessel or a part of the heart, look for it in the list so headed, and blacken the appropriate space on the answer sheet. Read each sentence completely before selecting the best terms to fill in the blanks.

Blood Vessels	*Parts of the Heart*
A. Aorta	**A.** Right auricle
B. Pulmonary artery	**B.** Right ventricle
C. Coronary artery	**C.** Left auricle
D. Pulmonary vein	**D.** Left ventricle
E. Superior or inferior Vena Cava	**E.** Sinus node

"Those who have acquired even the minimum of medical knowledge know how the heart is composed, and how all the blood in the veins can easily flow from the vena cava **174** into its right side **175** and from thence into the lung by the vessel we term the arterial vein **176**, and then return from the lung via **177** into the left side of the heart **178**, by the vessel called the venous artery **179**, and finally pass from there into the great artery **180**, whose branches spread throughout all the body. . . ."

(All the above items are classified as 1.20)

For items 181 - 194, after each item number on the answer sheet, blacken space

- **A.** if the item refers to blood platelets.
- **B.** if the item refers to lymph.
- **C.** if the item refers to red blood corpuscles.
- **D.** if the item refers to white blood corpuscles.
- **E.** if the item refers to blood plasma.

181. (1.20) In man, this substance is clear, carries no erythrocytes, and consists of about 90% water.

182. (1.20) It is estimated that there are about five million of these cells within a cubic millimeter of human blood.

183. (1.20) These disc-shaped cells are formed continuously in the red marrow of certain bones in man.

184. (1.20) Individuals who do not have a sufficient number of these cells suffer from a disease called anemia.

185. (1.20) There are about five thousand of these cells within a cubic millimeter of human blood.

186. (1.20) These cells have the power of independent movement and can pass through the walls of capillary blood vessels.

187. (1.20) These cells are destroyed in the human liver and spleen and their iron content is retained in the body.

188. (1.20) In man, these cells are concave on both sides and without nuclei when mature.

189. (1.20) In man, these cells are irregularly shaped and contain nuclei.

190. (1.20) Hemoglobin is found in these cells and performs the actual task of carrying oxygen to the cells of the human body.

191. (1.20) In man, the tiny spaces between cells are filled with this substance.

192. (1.20) These bodies tend to disintegrate quickly upon exposure of blood to air.

193. (1.20) Certain of these cells perform an important function by feeding upon bacteria, thus protecting the body against disease.

194. (1.20) In man, a good supply of these cells is necessary if cells of the body are to have a sufficient supply of oxygen.

For items 195 - 209, after the number on the answer sheet which corresponds to that of each of the following paired items, blacken space

- **A.** if the item in Column 1 is greater than that in Column 2.
- **B.** if the item in Column 2 is greater than that in Column 1.
- **C.** if the two items are of essentially the same magnitude.

	Column I		*Column II*
195. (1.20)	Volume of blood entering the right auricle.	....	Volume of blood entering the right ventricle.
196. (1.20)	The likelihood that the heart tissues obtain food, oxygen, etc., from the blood contained in the chambers.	....	The likelihood that the heart tissues obtain food, oxygen, etc., from the blood supplied to it through separate vessels.
197. (1.20)	The thickness of the wall of an artery.	....	The thickness of the wall of the corresponding vein.
198. (1.20)	The number of red blood cells per cubic mm. of blood.	....	The number of white blood cells per cubic mm. of blood.
199. (1.20)	The number of white blood cells per cubic mm. of blood of a normal healthy individual.	....	The number of white blood cells per cubic mm. of blood of an individual with acute appendicitis.
200. (1.20)	The amount of iron salvaged by the human body from the destruction of the red blood cells.	....	The amount of iron eliminated by the human body from the destruction of red blood cells.
201. (1.20)	The probability that an increase in carbon dioxide in the blood will affect the rate of the heart beat.	....	The probability that an increase of adrenalin in the blood will affect the rate of the heart beat.
202. (1.20)	The number of valves in arteries.	....	The number of valves in veins.

	Column I		Column II
203.	The amount of oxygen per cc. of the blood in the pulmonary arteries.	....	The amount of oxygen per cc. of the blood in the pulmonary veins.
204. (1.20)	The amount of oxygen per cc. in the blood in the venae cavae.	....	The amount of oxygen per cc. in the blood in the aorta.
205. (1.20)	The rate of flow of blood in arteries.	....	The rate of flow of blood in the capillaries.
206. (1.20)	The volume of blood passing through the venae cavae.	....	The volume of blood entering the right auricle.
207. (1.20)	The rate of flow of blood in a vein.	....	The rate of flow of blood in the corresponding artery.
208. (1.20)	Systolic blood pressure.	....	Diastolic blood pressure.
209. (1.20)	The pressure of blood in the venae cavae.	....	The pressure of blood in the aorta.

Below is given a free translation of an account of his work by William Harvey. It was written in Latin in 1616. Various sentences or a part of a sentence have been numbered to correspond to the numbers on the answer sheet. Black space

A. if the numbered statement indicates that Harvey established a fact by experimentation.
B. if the numbered statement indicates that Harvey arrived at a truth by deduction.
C. if the numbered statement concerns a fact established since Harvey's time.
D. if the numbered statement concerns an idea proven false since Harvey's time.
E. if the statement gives Harvey's theory of circulation.

(210) By William Harvey it has been shown from the structure of the heart that blood is carried across continuously through the lungs to the aorta as by two clacks of water bellows to raise water. **(211)** Through the use of ligatures the passage of blood from the arteries across to the veins has been shown. **(212)** Whence it has been proven that a perpetual motion of the blood in a circle is caused by the beat of the heart. **(213)** It is questionable whether this is for the sake of nourishment **(214)** or for greater preservation of blood **(214)** or of the organs by their receiving a warm bath **(215)** or whether on the contrary, the blood, cooled while warming the organs, is in this way warmed by the heart. (All the above items are classified as 1.20)

Items 216 - 229 refer to man. After each item number on the answer sheet, blacken space

A. if the item best associates the blood with a respiratory function.
B. if the item best associates the blood with a nutritive function.
C. if the item best associates the blood with an excretory function.
D. if the item best associates the blood with a protective function.

216. (1.20) Leucocytes are able to ingest bacteria.

217. (1.20) Hemoglobin is a chemical compound which unites readily with oxygen.

218. (1.20) Fats may enter the blood stream by way of the lymph ducts.

219. (1.20) Blood picks up insulin as it travels through the pancreas.

220. (1.20) Secretin is carried in blood plasma but only that which reaches the pancreas serves as a stimulator.

221. (1.20) The breaking down of amino acids in the liver releases ammonia which then is synthesized into urea.

222. (1.20) Platelets are fragile structures that readily disintegrate to form a substance essential to the clotting process.

223. (1.20) When a person moves to an altitude of 14,000 feet, where the oxygen concentration is low, his red blood cell count may rise in a short time to 6 - 8 million per cubic millimeter.

224. (1.20) Most persons carry a number of specific antibodies in their plasma.

225. (1.20) Digested carbohydrates, absorbed as glucose, may be stored in muscle cells as glycogen.

226. (1.20) Carbon dioxide diffuses out of the blood into an alveolus because its concentration is higher in the blood than in the lumen of the alveolus.

227. (1.20) If the concentration of sugar in the plasma is higher than 0.14 per cent the excess is not absorbed by the urinary tubule but [illegible]xcreted as a part of the urine.

228. (1.20) Every body cell builds protein out of the amino acids brought to it by the blood.

229. (1.20) The oxygen carried to every body cell, is used in the oxidation of food, a process that releases energy for the cell's activity.

230. (3.00) In attempting to determine his blood type a student found that clumping of his blood occurred with both serum from an A-type individual and serum from a B-type individual. This indicates that his blood type was

A. A. **B.** B. **C.** O. **D.** AB.
E. A or B, but not certain which.

231. (1.20) The relatively constant internal environment of the human body is made possible mainly by the

A. insulating effect of the skin.
B. digestive system and associated glands.
C. central nervous system. **D.** endocrine system.
E. circulatory system, sweat glands, liver, and kidneys.

232. (1.20) Which one of the following statements about proteins is most acceptable?

A. Some kinds of proteins can best be distinguished from each other by studying the living body's reaction to them.
B. Scientists have worked out the chemical formulas for over one hundred different kinds of proteins.
C. Repeated injections of certain protein foods into the blood stream is a means of prolonging the life of some hospital patients.
D. A protein molecule, generally speaking, is somewhat simpler in chemical structure than a fat molecule.
E. Under normal circumstances the body utilizes protein foods as its chief source of energy.

233. (1.20) A four-chambered heart is more efficient than any other type because

A. all four chambers carry freshly oxygenated blood.
B. more blood can be pumped in a given period of time.

C. one side of the heart rests alternately while the other side pumps blood.
D. the blood and lymph are circulated in separate systems.
E. freshly oxygenated blood is kept separated from unoxygenated blood.

Item 234 deleted.

235. (1.20) The immediate environment of internal body cells is

A. cartilage tissue. **B.** tissue fluid. **C.** the blood.
D. muscle tissue. **E.** epithelial tissue.

236. (1.20) Which of the following is not closely related to the others?

A. Acidophil. **B.** Basophil. **C.** Neutrophil.
D. Lymphocyte. **E.** Leucoplast.

237. (1.20) Fibrinogen of the blood is believed to play an important part in the

A. clotting of the blood.
B. transport of oxygen in the blood.
C. transport of carbon dioxide in the blood.
D. destruction of injurious bacteria.
E. formation of white corpuscles.

238. (1.20) Red blood corpuscles placed in pure distilled water will be likely to

A. undergo no appreciable change.
B. shrink considerably in size.
C. swell to the point of bursting.
D. lose their motility.
E. show considerable agglutination.

Item 239 deleted.

240. (1.20) The red corpuscles in blood flowing through the jugular vein differ from those in blood flowing through the pulmonary vein by

A. possessing less oxyhaemoglobin.
B. possessing more oxyhaemoglobin.
C. being smaller in size.
D. circulating more rapidly.
E. being brighter red in color.

241. (1.20) Blood flows fastest in

A. capillaries. **B.** large arteries.
C. medium sized arteries. **D.** medium sized veins.

242. (1.20) The blood pressure is highest in

A. large arteries. **B.** capillaries.
C. large veins. **D.** lacteals.

243. (1.20) Which of the following would not be found in the cross section of an artery from a person in normal health?

A. Connective tissue. **B.** Muscle tissue.
C. Cartilage tissue. **D.** Endothelial tissue.
E. Lumen.

244. (1.20) Defibrinated blood

A. will clot more readily than whole blood.
B. is blood which lacks white corpuscles.
C. is better than whole blood for transfusion into a hemophilic person just before an operation.
D. is blood which has had the red corpuscles removed.
E. would be worthless for transfusion into a hemophilic to stimulate clotting.

245. (1.20) When both atria and ventricles are completely relaxed from the heart contraction which has just been completed, the next contraction is initiated by

A. an impulse from the atrio-ventricular bundle.
B. an impulse from the sinus node.
C. flexing of the muscles of the atria.
D. opening of the aortic valve.
E. flexing of the muscles of the ventricles.

246. (1.20) Type A blood is incompatible with type B blood because the mixing of

A. antigen A with antibody B causes clumping of the red corpuscles.
B. antigen A with antibody A causes clumping of the red corpuscles.
C. antigen B with antibody A causes clumping of the red corpuscles.
D. More than one of the above is true.
E. None of the above is true.

247. (1.20) Those who belong to group AB can receive a blood transfusion from anyone, regardless of type, because

A. AB blood contains no antibody.
B. AB blood contains no antigen.
C. the Rh factor is always absent from type AB blood.
D. AB blood contains no calcium.
E. AB blood contains no thrombokinase.

Item 248 deleted.

249. (1.20) Increased heart rate of 10 to 12 beats per minute when a person, who has been reclining quietly, stands up would probably indicate that the person

A. has a weak heart. **B.** is physically normal.
C. might be a heavy smoker.
D. has an "athlete's heart."
E. is of a very nervous temperament.

250. (1.20) When the post-mortem examination reveals *coronary thrombosis* what has happened?

A. A bacterial infection of the heart muscle has caused its disintegration to the point where it could no longer function.
B. The individual's blood contained an insufficient number of red corpuscles and death resulted from deficiency of oxyhemoglobin supply to the body tissue.
C. Death was due to cerebral hemorrhage.
D. The individual was a bleeder and died from a failure of the blood to clot.
E. A blood clot has prevented oxygen and food from reaching the heart muscle tissue.

251. (1.20) Failure of the blood to clot readily when exposed to air may be due to

A. an oversupply of erythrocytes.
B. a deficiency of leucocytes.
C. a superabundance of fibrin.
D. the presence of an embolus.
E. an inadequacy of thrombokinase.

252. The *artery* that carries blood rich in carbon dioxide
(1.20) but with a low oxygen content is the

A. aorta. **B.** carotid. **C.** pulmonary.
D. iliac. **E.** subclavian.

253. If a capsule of potassium iodide is swallowed
(1.20)

A. the quick appearance of iodine in the salivary glands is due to complete absorption from the stomach.
B. absorption from the digestive tract is invariably more rapid in the female than in the male.
C. the potassium iodide will appear in the blood sooner after swallowing than it does in the saliva.
D. all of the iodine which is taken internally will be secreted by the salivary glands.
E. the only physical factor influencing absorption rate is the health condition of the subject.

254. The passage of water in and out of the blood stream
(1.20) of man is normally in a state of equilibrium. After a hemorrhage less water leaves the blood stream because of decreased

A. osmosis. **B.** phagocytosis. **C.** diffusion.
D. filtration. **E.** number of red blood cells.

255. A heart beat consists of the alternate contraction and
(1.20) relaxation of heart muscle. Although the flow of blood should occur only during contraction, the circulation of blood in vessels is practically continuous because

A. the heart maintains the blood pressure during relaxation.
B. the next beat occurs soon enough to keep the blood flowing.
C. the vessels are drained in refilling the heart.
D. gravity is acting continuously.
E. the aorta takes over while the heart relaxes.

256. Exchange of substances between the blood and the
(1.20) body cells takes place through the environment common to both, which is the

A. cell wall. **B.** endothelial layer.
C. tissue fluid. **D.** blood plasma.
E. connective tissue layer.

257. Which of the following is unique about capillaries as
(1.20) a kind of blood vessel?

A. The blood usually flows through them in one direction.
B. A capillary has a lumen or bore.
C. Diffusion of substances into and out of these vessels is possible.
D. Capillaries have an endothelium.
E. The formed elements of the blood are here carried in the plasma.

258. The number of white blood cells per cc. of blood when
(1.20) there is *severe infection* in the body is

A. greater than **B.** less than
C. the same as the number of white blood cells per cc. of blood when the body is in *good health.*

Directions for item 259—The following paired statements refer to structures, functions, or factors which are to be compared in the quantitative sense. For each item mark space

A. if the entity described on the left *is greater than* that on the right.
B. if the entity described on the left *is less than* that on the right.
C. if the left and right are *essentially the same.*

259. (1.20) The number of red corpuscles per cc. of blood when an individual is anemic is	**1.** greater than **2.** less than **3.** the same as	the number of red corpuscles per cc. of blood when an individual *is in good health.*

260. Which of the following is the first to break the proper
(1.20) sequence?

A. Left auricle. **B.** Pulmonary vein.
C. Bicuspid valve. **D.** Left ventricle.
E. Semilunar valves.

261. Which of the following structures is (are) found in
(1.20) veins but not in arteries?

A. Muscles. **B.** Valves. **C.** Connective tissue.
D. Endothelial cells. **E.** Interior cavity.

262. In the following pair, blacken space A if the first ele-
(1.20) ment of the pair is definitely greater than the second; space B if the second is definitely greater than the first; and space C if the two are approximately equal.

1. Normal heart rate of a child.
2. Normal heart rate of a man.

263. In the following pair, blacken space A if the first ele-
(1.20) ment of the pair is definitely greater than the second; space B if the second is definitely greater than the first; and space C if the two are approximately equal.

1. Affinity of carbon monoxide for hemoglobin.
2. Affinity of oxygen for hemoglobin.

264. All the blood from the digestive tract is drained by
(1.20) the portal vein which directly carries the blood to the

A. hepatic vein. **B.** vena cava. **C.** colon.
D. liver. **E.** pancreas.

265. The movement of materials in ameba is carried out by
(1.20) means of

A. absorption. **B.** filtration. **C.** capillary action.
D. diffusion and flowing of cytoplasm.
E. a circulatory system.

266. In the following pair, blacken space **A** if the first ele-
(1.20) ment of the pair is definitely greater than the second; space **B** if the second is definitely greater than the first; and space **C** if the two are approximately equal.

1. Carbon dioxide concentration in the pulmonary artery.
2. Carbon dioxide concentration in the pulmonary vein.

267. In the following pair, blacken space **A** if the first ele-
(1.20) ment of the pair is definitely greater than the second; space **B** if the second is definitely greater than the first; and space **C** if the two are approximately equal.

1. Number of red cells in a drop of blood.
2. Number of white cells in a drop of blood.

268. In the following pair, blacken space **A** if the first ele-
(1.20) ment of the pair is definitely greater than the second;

space **B** if the second is definitely greater than the first; and space **C** if the two are approximately equal.

1. Capillary blood pressure.
2. Venous blood pressure.

269. (1.20) In the following pair, blacken space **A** if the first element of the pair is definitely greater than the second; space **B** if the second is definitely greater than the first; and space **C** if the two are approximately equal.

1. Rate of flow of blood in veins.
2. Rate of flow of blood in capillaries.

270. (1.20) The composition of the blood in man's body may be characterized as

A. static and unchanging.
B. fluctuating widely, maintaining no semblance of constancy.
C. maintaining itself in a state of dynamic equilibrium.
D. a homogeneous, red, viscous fluid.
E. none of the above.

Items 271 - 272 deleted.

273. (1.20) The tricuspid valve lies between the

A. left auricle and the left ventricle.
B. right auricle and the right ventricle.
C. right ventricle and the pulmonary artery.
D. left ventricle and the aorta.
E. left auricle and the right auricle.

274. (1.20) In the event of a blood transfusion, of the following situations the one which would not cause coagulation of the blood of the recipient is

A. B donor with A recipient.
B. A donor with AB recipient.
C. AB donor with B recipient.
D. B donor with O recipient.
E. O donor with B recipient.

275. (1.20) The sequence of events in the clotting of the blood is

A. prothrombin + thrombin + calcium → fibrin.
B. prothrombin + thrombin + calcium → fibrin.
thrombokinase + fibrin → fibrinogen.
C. thrombin + thrombokinase + calcium → fibrinogen.
fibrinogen + prothrombin → fibrin.
D. prothrombin + thrombokinase + calcium → thrombin.
thrombin + fibrinogen → fibrin.
E. prothrombin + fibrinogen → thrombin.
thrombin + thrombokinase + calcium → fibrin.

Item 276 deleted.

277. (1.20) The path followed by the blood is

A. right auricle – left auricle – lungs – right ventricle – left ventricle – systemic circuit.
B. left auricle – left ventricle – lungs – right auricle – right ventricle – systemic circuit.
C. right ventricle – left ventricle – systemic circuit – right auricle – left auricle – lungs.
D. right auricle – right ventricle – lungs – left auricle – left ventricle – systemic circuit.
E. right ventricle – left ventricle – lungs – left auricle – right auricle – systemic circuit.

278. (1.20) In living tissues of an embryo cultured artificially, it is possible to distinguish with the naked eye heart muscle from diaphragm muscle because

A. the muscle tissue from the diaphragm is striated.
B. the muscle tissue from the diaphragm is made up of spindle-shaped fibers.
C. the cells making up diaphragm muscle tissue are nucleated.
D. the heart muscle tissue is striated.
E. the heart muscle tissue is self-activating.

279. (1.20) The capillaries

A. have no true muscles in their walls.
B. resemble arteries except that they are smaller.
C. resemble veins except that they are smaller.
D. alternately contract and expand in rhythm with the heart beat, forcing the blood on its way through them.
E. have three layers in their walls.

280. (1.20) The apparent size of a bird is greater on a cold day because

A. external cold so affects our eyes as to make objects look larger to us under those conditions.
B. the reduction in body temperature of the bird causes it to expand.
C. the feathers are not lying as flat on the body as usual.
D. external cold causes the bird reflexly to route more of its blood to the internal regions of the body.
E. of none of the above.

281. (1.20) Blood circulating to the toes leaves the heart from the

A. right auricle. **B.** right ventricle.
C. left auricle. **D.** left ventricle.
E. atrioventricular node.

282. (1.20) Failure of the blood to clot readily when exposed to air may be due to

A. an oversupply of erythrocytes.
B. a deficiency of leucocytes.
C. a superabundance of fibrin.
D. the presence of an embolus.
E. an inadequacy of thrombokinase.

283. (1.20) Four of the following are found in the blood plasma. Which one is not found in the plasma but is a component of the cellular portion of the blood?

A. Fibrinogen. **B.** Adrenalin being transported.
C. The anti-A antibody.
D. Nitrogenous waste in transport. **E.** Hemoglobin.

284. (1.20) Four of the following factors play a role in helping to maintain the relative constancy of the red corpuscle number in human blood. Which one is not *directly* related to this function?
A. Oxygen availability.
B. Condition of the bone marrow.
C. Functioning of the liver.
D. Functioning of the spleen.
E. Functioning of the gall bladder.

285. The relative number of white cells present in the blood
(1.20) from time to time may depend upon

- **A.** the presence or absence of infective agents in the body.
- **B.** the altitude at which the individual lives.
- **C.** the amount of iron in the individual's diet.
- **D.** the sex of the individual—whether male or female.
- **E.** none of the above factors.

286. Blood entering the heart from the posterior vena cava
(1.20) has most recently been in the

A. finger tips. **B.** brain. **C.** lower abdomen.
D. lungs. **E.** left ventricle.

287. The blood in the superior vena cava
(1.20)

- **A.** has been freshly oxygenated.
- **B.** is enroute to the heart laden with carbon dioxide absorbed from the body tissue.
- **C.** has just left the heart and is enroute to the lungs for oxygenation.
- **D.** is returning to the heart from the lungs.
- **E.** has just left the heart and is enroute to the body extremities.

288. The circulation of the lymph differs from the circulation of the blood in man in that
(1.20)

- **A.** the lymph vessels do not form a continuous closed system.
- **B.** the motion of the lymph is derived from contraction of the nodes rather than a central heart.
- **C.** no provision is made for destruction of harmful bacteria.
- **D.** the lymph vessels are not branched.
- **E.** none of the above; there are no differences.

289. What is likely to be the consequence if a person has
(1.20) blood platelets which do not disintegrate very readily?

- **A.** He may die from agglutination in the capillaries.
- **B.** He may be a bleeder.
- **C.** He would likely be subject to coronary thrombosis.
- **D.** He is likely to be anemic.
- **E.** There is greater than average likelihood that his death will be caused by a blood clot lodged in one of the capillaries in the brain.

290. The structure of capillaries, when compared with
(1.20) arteries, reveals

- **A.** no differences.
- **B.** the lack of endothelium, muscle, and connective tissue in capillaries.
- **C.** a larger number of valves in the capillaries.
- **D.** only one kind of tissue common to both.
- **E.** the capillaries to be microscopic arteries.

291. Judging on the basis of function performed, which portion of the heart would be likely to have the thickest wall?
(1.20)

A. Left ventricle. **B.** Right ventricle.
C. Left auricle. **D.** Right auricle. **E.** Pericardium.

292. What does the statement that a person with type O
(2.10) blood is a universal donor actually mean?

- **A.** Type O blood can be transfused in any quantity into the blood stream of a recipient regardless of the recipient's blood type.
- **B.** The percentage of the population having type O blood is so large in comparison to all other types combined that it is regarded as practically universal.
- **C.** A person with type O blood has least to worry about if he should require a transfusion.
- **D.** A person with Type A, B, or AB blood can receive type O blood if it is transfused slowly and in small quantity at one time.
- **E.** Type O blood does not have to be matched on the basis of any other antigen factor before being transfused.

For item 293, after the exercise number on the answer sheet blacken the one lettered space which designates the most similar structure, condition, or process.

293. The function of the nodal tissues of the heart:
(2.10)

- **A.** The function of the epithelium of a villus.
- **B.** The function of the nephridia of an earthworm.
- **C.** The function of a traffic officer at an airport.
- **D.** The function of part of the tissue of a lymph node.
- **E.** The function of the islet tissue of the pancreas.

For item 294, after the exercise number on the answer sheet blacken the one lettered space which designates the most similar structure, condition, or process.

294. The action of the liver on old red blood corpuscles:
(2.10)

- **A.** The action of the enzyme in the saliva on starch.
- **B.** The act of changing the oil in an automobile engine.
- **C.** The action of chlorophyll in photosynthesis.
- **D.** The action of an acid in dissolving a metal.
- **E.** The action of patriotic individuals in salvaging the rubber in worn-out tires.

For item 295, after the exercise number on the answer sheet blacken the one lettered space which designates the most similar structure, condition, or process.

295. The shape of an ameba:
(2.10)

- **A.** The shape of a paramecium.
- **B.** The shape of a white blood cell.
- **C.** The shape of a red blood cell.
- **D.** The shape of a bacillus.
- **E.** The shape of a neurone.

For items 296 - 299 use the following key to indicate the movement of water in each situation.

KEY

- **A.** Water would be reduced in the living cell(s).
- **B.** Water would be increased in the living cell(s).
- **C.** Water would remain about the same in the living cell(s).
- **D.** Impossible to determine what would happen.

296. Normal red blood corpuscles in distilled water.
(2.20)

297. Normal red blood corpuscles in Ringer's solution.
(2.20)

298. Normal red blood corpuscles in 5% salt solution.
(2.20)

299. An ameba transferred from a beaker of fresh water to
(2.20) a beaker of ocean water.

300. (2.20) Which of the following is evidence that substantiates the hypothesis: "The protoplasm of each species includes at least one unique protein?"

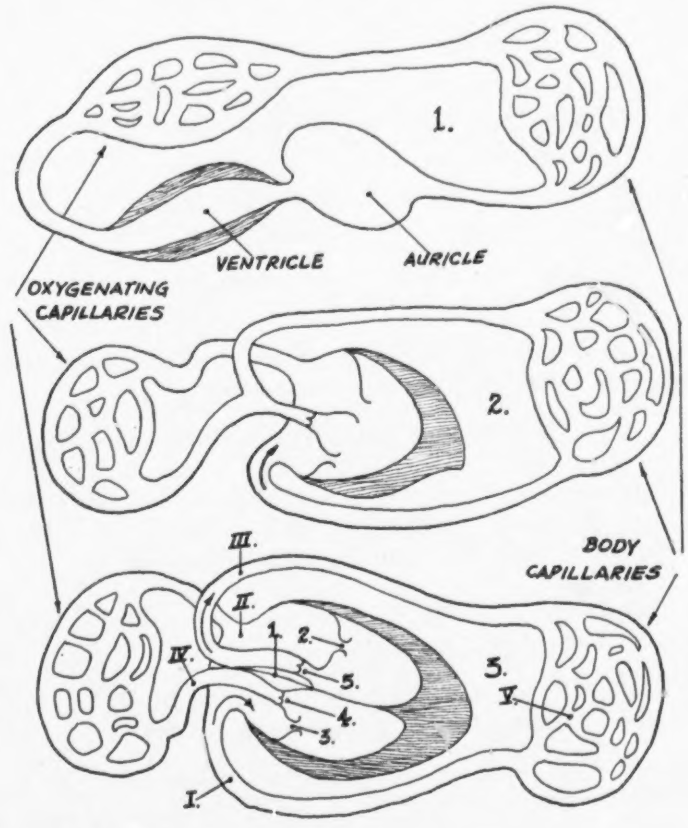
- **A.** The "Rh" factor of the blood.
- **B.** The "A" factor of the blood.
- **C.** The "B" factor of the blood.
- **D.** The "N" factor of the blood.
- **E.** None of the above.

301. (2.20) In which of the following situations is the molecule an integral part of the internal environment of the organism?

- **A.** A molecule of oxygen in an air sac of the lung of a frog.
- **B.** A molecule of water in the stomach of a turtle.
- **C.** A molecule of nitrogenous waste in the ureter of a chicken.
- **D.** A molecule of sugar in the blood of man.
- **E.** A molecule of protein in the cavity of the human intestine.

302. (2.20) Mr. Jones is always "short of breath" or has a very high breathing rate. Which statement below is best associated with this condition?

- **A.** His red blood cells are deficient in hemoglobin.
- **B.** He has less than the normal number of red blood cells per cu. mm.
- **C.** His red bone marrow is underactive.
- **D.** His thyroid gland is overactive.
- **E.** Any one of the above could cause these symptoms.



Items 303 - 307 refer to the diagram.

303. (2.20) The schematic system or systems that show the greatest evolutionary advancement as interpreted by the criterion of requiring all the blood to be oxygenated before being returned to the body tissues is or are

A. 1 and 2. **B.** 2 and 3. **C.** 1 and 3.
D. all three. **E.** none of the three.

304. (2.20) The schematic system or systems that show the greatest evolutionary advancement as interpreted by the single criterion of requiring the oxygenated blood to be delivered under the greatest possible pressure to all body tissues is or are

A. 1. **B.** 2. **C.** 3. **D.** 1 and 2. **E.** 2 and 3.

305. (2.20) In diagram number 3, the point of marked weakness in a newborn child is indicated by which Arabic number?

306. (2.20) On the assumption that bacteria from body infections will lodge in the heart and produce structural damage, which Arabic number in diagram 3 marks the point where damage would be most probable to develop first?

307. (2.20) The approximate point at which the lymphatic system empties digested fats into the blood stream is marked by which Roman numeral?

308. (2.20) All except which one of the following would tend to substantiate the belief that the blood circulates through the body in *one* direction?

- **A.** People who suffer from hardening of the arteries tend to have poor circulation in the lower limbs.
- **B.** Closing off (with clamps) both vena cavas and the pulmonary vein in an anaesthetized experimental animal causes the two auricles of the heart to collapse.
- **C.** If the aorta and pulmonary artery are closed off in an anaesthetized animal the two ventricles of the heart tend to swell up.
- **D.** Blocking of an artery in a live animal causes an accumulation of blood in that artery on the side toward the heart.
- **E.** Cutting a large artery in a live animal causes blood to spurt out from only one cut end.

For items 309 - 311 use the following key:

KEY

- **A.** A blood sample is allowed to fill a capillary tube. After 2 minutes the tube is broken and the contents observed.
- **B.** A sealed glass tube containing water has a small portion of a soluble dye in the bottom. The tube is observed at intervals.
- **C.** A diluted sample of blood is treated with a variety of serum obtained from other people and then subjected to microscopic examination.
- **D.** Samples of blood containing sodium oxalate are treated with potassium chloride, calcium chloride, and sodium chloride. The samples are observed after shaking.
- **E.** Blood samples are allowed to be absorbed by a special kind of test paper. The paper is then compared with a standardized scale.

309. (2.20) The hemoglobin content of blood varies among individuals under variable circumstances.

310. (2.20) The rate of clotting of blood varies among individuals under variable circumstances.

311. (2.20) The blood type of all military individuals was required to be stamped on their identification tags.

312. (2.20) Which of the following is *not* occurring in the human fetus just prior to birth?

- **A.** Circulation through the systemic circuit.
- **B.** Cellular respiration.
- **C.** Circulation through the pulmonary circuit.

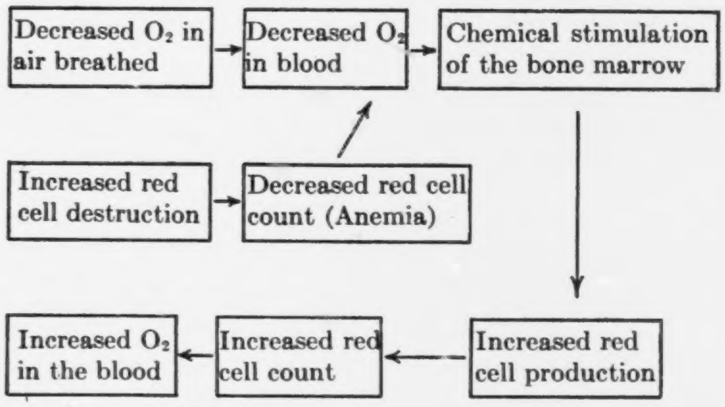
- **D.** Discharge of nitrogenous waste into the blood stream.
- **E.** Mitosis.

Item 313 deleted.

314. (2.20) Which of the following would characterize blood that is flowing through the pulmonary veins?

- **A.** It contains more CO_2 than blood in any other part of the body.
- **B.** It is purplish red rather than scarlet red in color.
- **C.** It has been freshly oxygenated.
- **D.** It contains more red corpuscles per cc. than blood in any other part of the body.
- **E.** Its composition is no different than that of blood in other parts of the body.

Items 315 - 320 are concerned with the principles which underlie the following diagram.


Decreased O₂ in air breathed
Decreased O₂ in blood
Chemical stimulation of the bone marrow
Increased red cell destruction
Decreased red cell count (Anemia)
Increased O₂ in the blood
Increased red cell count
Increased red cell production

For items 315-320 mark each statement according to the following key:

KEY

- **A.** The statement is probably *true.*
- **B.** The statement is probably *false.*
- **C.** Biological science offers *no basis on which to judge* the truth or falsity of the statement.

315. (2.20) If an individual who has lived for many years in Miami, Florida moves to Denver, Colorado, he is likely to experience a decrease in erythrocyte count within a few months after moving.

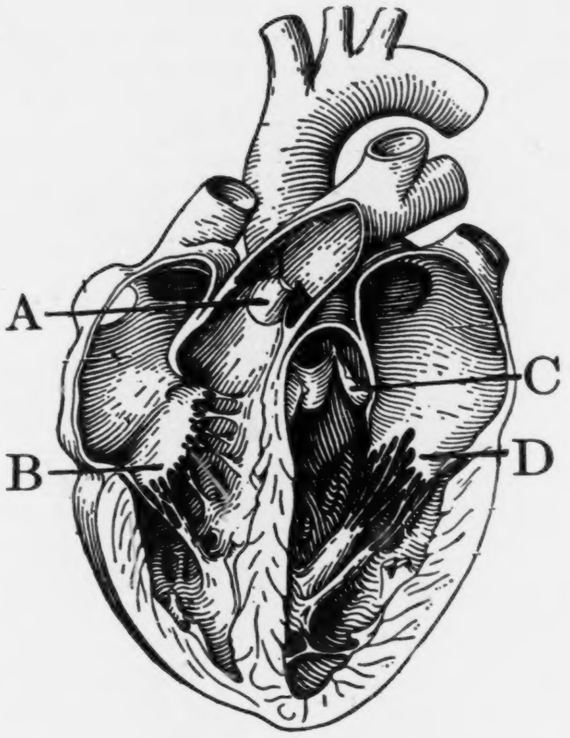
316. (2.20) The blood of a factory employee who paints *luminous* figures on watch and clock dials will tend to show a higher hemoglobin percentage than the blood of an employee who assembles the mainsprings for the clocks and watches.

317. (2.20) Within limits, man's body will compensate to meet changed demands made upon it.

318. (2.20) Serving as a blood donor, even to the extent of giving only one pint of blood, does a certain amount of irreparable damage to the body.

319. (2.20) If a crayfish or lobster accidentally loses a nipper or leg the missing part will eventually be replaced by regeneration of a new one, but if a man accidentally loses a finger, no new finger will develop to replace it; *therefore it can be said that man lacks the power of biological regeneration.*

320. The diagram above demonstrates that a deficiency of a substance can serve as a stimulus.



The muscle of this heart has been cut in such a way that its four sets of valves can be seen. Answer the items 321 - 326 by blackening the space for the letter referred to in the diagram.

321. (2.20) The valve located between the right auricle and right ventricle.

322. (2.20) The valve located at the base of the aorta.

323. (2.20) The valve between the left auricle and ventricle.

324. (2.20) When the blood passes through this valve it is in the pulmonary artery.

325. (2.20) The valve that prevents blood from flowing back into the left ventricle.

326. (2.20) The valve that prevents blood from flowing back into the right auricle.

327. (3.00) Right after climbing a mountain there are more red cells in the blood than before because

- **A.** the bone marrow is stimulated to produce more new red cells.
- **B.** the red cells stored in the spleen are released with the blood.
- **C.** the spleen is stimulated to produce more new red cells.
- **D.** the red cells stored in the bone marrow are released into the blood.

Items 328 - 341 are concerned with the possible explanation of what causes the heart to beat. Consider the following.

Hypothesis: The heart has an independent system within itself which *initiates* the heart beat.

Answer items 328 - 341 by using the following key. (Suggestion—it may be helpful first to classify the items as true or false.)

KEY

- **A.** A statement which is *true,* and tends to support the hypothesis.
- **B.** A statement which is *true,* and tends to refute the hypothesis.

C. A statement which is *false*, but which, if it were true, would tend to support the hypothesis.
D. A statement which is *false*, but which, if it were true, would tend to refute the hypothesis.
E. A statement which is *irrelevant* to the hypothesis, regardless of its truth or falsity.

328. (3.00) In an anesthetized animal the heart continues to beat even after all nerves leading to it are severed.

329. (3.00) A pair of accelerator nerves from the medulla tend to speed up the heart rate in a normal living mammal.

330. (3.00) The heart continues to beat after it is removed completely from the anesthetized animal's body.

331. (3.00) A few drops of warm Ringer's (nutrient) solution sprayed on the heart of a freshly anesthetized, dissected frog causes the heart rate to accelerate.

332. (3.00) A piece of heart tissue cut from the wall between the auricles continues to contract longer and more vigorously than a piece of heart tissue cut from the lower tip of the ventricles.

333. (3.00) The valves of the heart open in one direction only.

334. (3.00) The heart rate accelerates when the animal or person is frightened.

335. (3.00) In an anesthetized animal if the Vagus nerves leading from the medulla are cut, the heart will beat faster.

336. (3.00) An excised frog's heart which has stopped beating for one hour can be revived and made to resume beating if adrenalin and Ringer's solution are sprayed over it.

337. (3.00) Rate of heart beat is regulated by the autonomic nervous system.

338. (3.00) The heart has a set of blood vessels within itself which supply its own tissues with blood.

339. (3.00) The heart rate can be regulated by stimuli originating in the cerebrum.

340. (3.00) A frog's heart is three-chambered, while a mammalian heart is four-chambered.

341. (3.00) When the nerve tissue from a freshly excised king crab's heart is removed, the result is immediate cessation of its beating. (This statement is a fact.)

For item 342, after the exercise number on the answer sheet blacken the one lettered space which designates the most similar structure, condition, or process.

342. (3.00) The function of the cells surrounding each stomate:

A. The function of cells in the islet tissue of the pancreas.
B. The function of the flame cells in a flatworm.
C. The function of the nematocysts of a hydra.
D. The function of the valves in a vein.
E. The function of white blood corpuscles.

343. (3.00) In phosphorus poisoning the liver produces less fibrinogen. This

A. increases the clotting time of blood.
B. decreases the clotting time of blood.
C. increases lymphocyte production.
D. increases the rate of the heart beat.
E. has little or no effect.

344. (3.00) In the disease hemophilia, the blood platelets disintegrate slower than normally. This

A. prolongs the clotting time of blood because calcium ions would not be released rapidly.
B. shortens the clotting time because the number of whole blood platelets determines the rapidity of clotting.
C. prolongs the clotting time because thromboplastin would not be released rapidly.
D. has little if any effect on the clotting time.
E. prolongs the clotting time because fibrin is released slowly.

345. (3.00) When it is inhaled, carbon monoxide chemically combines with hemoglobin. This would rapidly

A. cause arterial blood pressure to rise.
B. increase the amount of oxygen going to the tissues.
C. decrease the amount of oxygen going to the tissues.
D. increase the clotting time of blood.
E. cause dilation of all veins.

346. (3.00) In attempting to determine his blood type a student found that clumping of his blood occurred with both A-serum and B-serum. This indicates that his blood type was

A. A. **B.** B. **C.** O. **D.** AB.
E. A or B, but not certain which.

347. (3.00) The disintegration of blood platelets is impaired.

A. The production of red blood corpuscles is reduced.
B. The clotting of blood is affected.
C. An embolus is likely to form.
D. Thrombosis may result.
E. Nothing abnormal will happen.

For items 348 - 351, after the number on the answer sheet which corresponds to that of each of the following physiological reactions, blacken the *one* lettered space which designates the item at the right that best describes the adaptive significance (i.e., value of the organism) of the reaction.

	Physiological Reactions		*Adaptive Significance*
348. (3.00)	When environmental temperature falls the skin blood vessels constrict.	**A.**	This aids in correlating the activity of the part with the quantity of blood going to it per minute.
349. (3.00)	Blood vessels going to skeletal muscles dilate during exercise.	**B.**	Excessive heat radiation is prevented.
350. (3.00)	When environmental temperature falls, metabolism is increased.	**C.**	Enables each cc. of blood to carry about as much oxygen as under more usual environmental conditions.
351. (3.00)	Acclimation to high altitudes involves an increase in red blood cells.	**D.**	Increased heat loss is offset by increased heat production.
		E.	Contraction of skeletal muscle forces venous blood back to the heart.

352. (3.00) Plasma alone is to be used in a transfusion. What must be known?

A. The blood group of the donor.
B. The blood group of the recipent.

C. The blood group of both donor and that of recipient.
D. None of these.

353. (3.00) In the human fetus just prior to birth there is a large opening allowing blood to flow directly between the left and right auricles. From this it could be inferred that the

A. heart does not function prior to birth.
B. pulmonary system does not function prior to birth.
C. heart of the fetus carries unoxygenated blood only.
D. heart of the fetus carries oxygenated blood only.
E. ventricles alone of the fetal heart are functional prior to birth.

For items 354 - 358 select the substance named in the key which would be most appropriate for the use or need indicated.

KEY

A. Whole blood. B. Plasma.
C. Serum globulin. D. Blood grouping serum.
E. Fibrinogen and thrombin.

354. (3.00) An accident victim in a remote area shows symptoms of severe shock.

355. (3.00) A child is exposed to measles.

356. (3.00) Several days after being admitted to a hospital a patient develops symptoms of anemia.

357. (3.00) A man is preparing for hazardous employment.

358. (3.00) A severely burned patient enters a hospital.

359. (3.00) Four individuals, W, X, Y, and Z were interested in their blood types. Individual Z knew that he was of type O. In which of the following cases could the blood type of one of the other individuals be definitely determined?

A. Z's serum clumped the corpuscles in a sample of X's blood.
B. Z's serum clumped the corpuscles in a sample of Y's blood.
C. X's serum did not clump the corpuscles in a sample of W's blood.
D. Z's serum did not clump the corpuscles in a sample of W's blood.
E. None of the above.

360. (3.00) The semilunar valves do not flap into the cavity of the ventricle when the ventricle relaxes since

A. the valves are built as pockets opening toward the ventricle.
B. the valves are built as pockets opening toward the artery.
C. the valves are attached by tendons at their "free" ends to the inner wall of the ventricle.
D. the pressure inside the artery is greater than inside the ventricle.
E. none of the foregoing, since the valves do flap into the ventricle.

361. (3.00) As a last resort when other treatment for extremely high blood pressure has failed an operation is sometimes performed. Judging from the basic cause of blood pressure, which one of the following would most likely be done in such an operation?

A. Some of the veins in the lower limbs are removed.
B. One branch of the vagus nerve leading to the heart is cut in an attempt to reduce the frequency of the heart beat.
C. A branch of vasomotor nerves which regulate contraction of certain blood vessels is cut.
D. The patient's spleen is removed.
E. Some of the bone marrow in the larger bones of the body is inactivated.

362. (3.00) If lymph ceased to circulate which of the following would be most directly affected?

A. Fat digestion.
B. Transport between the body cells and the blood.
C. Production of red blood cells.
D. Lymphatic absorption of carbohydrates.
E. Circulation of blood platelets.

363. (3.00) What is likely to be the consequence if a person has blood platelets which do not disintegrate very readily?

A. He may die from agglutination in the capillaries.
B. He may be a bleeder.
C. He would likely be subject to coronary thrombosis.
D. He is likely to be anemic.
E. There is greater than average likelihood that his death will be caused by a blood clot lodged in one of the capillaries in the brain.

364. (3.00) A patient who has had a hemorrhage is given, by accident, a liberal injection of distilled water into one of his veins. This would

A. have no unfavorable effect as long as the water is free of germs.
B. be fatal, because there would be too much fluid.
C. probably be fatal, because the red blood cells would rupture.
D. probably be fatal, because the red blood cells would shrivel.
E. have no serious effect because "thinning" of the blood is a natural phenomenon.

365. (3.00) The immediate environment of the cells of a mammal is maintained constant within narrow limits as a result of the nearly constant composition of

A. blood in the entire extent of all systemic arteries.
B. blood in the entire extent of all systemic veins.
C. blood in the entire extent of all tissue capillaries.
D. lymph in lymphatic vessels.
E. the external environment.

In the following groups of items 366 - 393, a component of blood (printed in italic capitals) is followed by a numbered series of organs or tissues.

Directions: For each organ or tissue under *normal* circumstances in the adult mammal, *blacken* answer space

A. if some of that component of blood *leaves* the blood passing through capillaries in the organ or tissue.
B. if some of that component of blood *enters* the blood passing through capillaries in the organ or tissue.
C. if some of that component of blood is *used up by chemical reactions* inside the capillaries in the organ or tissue.
D. if some of that component of blood is *produced by chemical reactions* inside the capillaries in the organ or tissue.

E. if that component neither enters nor leaves the blood, nor is chemically altered in blood in the capillaries of the organ or tissue.

GLUCOSE (disregard the amount metabolized by the cells in the blood) . . . .

366. (3.00) A gland in the small intestine full of food.

367. (3.00) Intestinal villus in absorptive portion of small intestine full of digested food.

368. (3.00) Liver during absorption of food following a large well-balanced meal.

369. (3.00) Bowman's capsule of kidney tubule.

370. (3.00) Absorptive portion of kidney tubule.

371. (3.00) Active skeletal muscle.

372. (3.00) Heart.

373. (3.00) Lungs.

374. (3.00) Brain.

375. (3.00) Kidney as a whole.

REDUCED HEMOGLOBIN (Give all correct answers for each of items 376 - 380) . . . .

376. (3.00) Red bone marrow.

377. (3.00) Lungs.

378. (3.00) A gland in the wall of small intestine (jejunum) full of digesting food.

379. (3.00) Active skeletal muscle.

380. (3.00) Absorptive portion of kidney tubule.

GASTRIN . . . .

381. (3.00) Wall of stomach which contains protein food.

382. (3.00) Wall of duodenum with alkaline contents.

383. (3.00) Wall of duodenum with acid contents.

384. (3.00) Thyroid.

CALCIUM ION . . . .

385. (3.00) Growing bone.

386. (3.00) Growing teeth.

387. (3.00) Mammary glands during lactation.

388. (3.00) Intestinal villus of absorptive portion of small intestine with digested food.

A PLASMA PROTEIN . . . .

389. (3.00) Bowman's capsule of kidney tubule.

390. (3.00) Secretory portion of kidney tubule.

391. (3.00) Intestinal villus in absorptive portion of small intestine containing digested food.

392. (3.00) Lungs.

393. (3.00) Active skeletal muscle.

394. (3.00) In Chile, the Indians who live in the Andes have a higher concentration of red cells in their blood than have the inhabitants of the sea coast, because:

A. red-skinned peoples need more blood cells to maintain their skin color.
B. they work harder.
C. the air they breathe has a lower percentage of oxygen.
D. the air they breathe has a lower total content of oxygen.
E. the air they breathe has a higher total content of carbon dioxide.

395. (3.00) What is likely to happen when the lymph *production* rate exceeds the *return* rate?

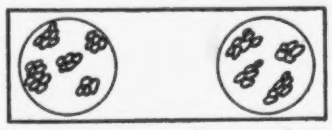
A. The result is likely to be death from rupture of a lymphatic vessel.
B. The pancreas will not be able to produce sufficient insulin, and diabetes may be the ultimate result.
C. There is likely to be undue accumulation of fluid in the spaces between cells, resulting in swollen ankles or other body parts.
D. The muscles will be overstimulated.
E. The supply of red corpuscles will be drastically reduced, resulting in severe anemia.

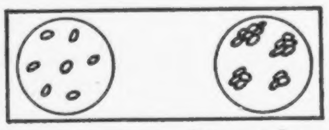
396. (3.00) During prenatal life, the human heart has an opening between the two auricles. In a few rare cases this opening persists into adulthood. What effect would this persistence be likely to have on the athletic abilities of the individual?

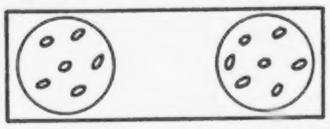
A. The individual would probably be able to develop into a super-athlete because his blood would get oxygenated twice, instead of once, each time it traveled around the body circuit.
B. The individual could live a normal life and participate in athletics like any other average person.
C. The individual would probably have to live a relatively non-strenuous life because his blood would likely be oxygen-poor most of the time.
D. Very rarely would such an individual live to be old enough to participate in athletics.
E. It would have no marked effect, but if an opening persisted between the two ventricles the individual's athletic ability would be greatly impaired.

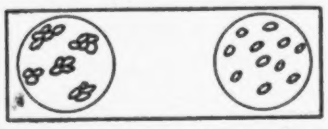
Items 397 - 401 are concerned with reactions of various blood types to different types of serum. The key represents microscope slides on which the blood sample referred to in each item is identified. For each item select from the key the slide that applies and mark the corresponding answer space.

Key

1

Serum from type A individual **Serum from type B individual**

3

Serum from type A individual **Serum from type B individual**

2

Serum from type A individual **Serum from type B individual**

4

Serum from type A individual **Serum from type B individual**

397. (3.00) Which slide represents the blood of an individual who could give a transfusion to anyone regardless of the type of blood possessed by the recipient?

398. (3.00) Which slide represents the blood of an individual who could receive blood in a transfusion from anyone regardless of the type of blood possessed by the donor?

399. (3.00) Which slide represents type B blood?

400. (3.00) Which slide represents blood lacking antibody a?

401. Which slide represents blood lacking antibody b?

402. (3.00) A red corpuscle at equilibrium in a 0.9% sodium chloride solution is transferred to another sodium chloride solution, the concentration of which is 0.2%. The ultimate fate of the corpuscle will be

A. no marked change. **B.** considerable shrinkage.
C. swelling to the point of bursting.
D. color change to white. **E.** none of the above.

403. (3.00) Congestion of the lungs, occurring in certain diseases, stops the circulation through the lungs. One would expect to find on post-mortem examination

- **A.** the right side of the heart distended (enlarged and filled with blood).
- **B.** the left side of the heart distended.
- **C.** the two upper cavities of the heart distended.
- **D.** the two lower cavities of the heart distended.
- **E.** only the left auricle distended.

404. (3.00) If a person's blood count had been taken periodically and the white cell number increased over a period of time to 18,000 per cubic millimeter, it may be an indication that the person has

A. high blood pressure. **B.** anemia.
C. abscessed teeth. **D.** hemophilia.
E. hardening of the arteries.

405. (3.00) A stroke may be impending when an embolus is moving through one of the

A. subclavian arteries. **B.** iliac arteries.
C. pulmonary arteries. **D.** brachial arteries.
E. carotid arteries.

406. (3.00) Which of the following is likely to occur if a type AB individual receives type O blood slowly in a transfusion?

- **A.** The antibodies in his serum will cause the antigens in the corpuscles of the transfused blood to agglutinate.
- **B.** The relatively large amount of antibody material brought in by the transfused blood is likely to cause his own blood to agglutinate.
- **C.** The type O antibodies will cause many of the corpuscles of the AB blood to disintegrate.
- **D.** The recipient in the transfusion is likely to suffer no ill effects.
- **E.** There is no basis for making any prediction in this case.

407. (3.00) When obtaining a blood sample from your finger for use in a laboratory study on blood typing you were directed to place a drop of blood in a vial containing 20 drops of physiological salt solution (0.9% sodium chloride). Why was this solution used in preference to distilled water?

- **A.** The physiological salt solution supplied certain nutritional elements which were needed by the blood cells.
- **B.** The blood cells would be likely to shrink to half their size if placed in distilled water.
- **C.** The physiological salt solution was used because it served as safeguard against bacterial growth.
- **D.** The red corpuscles would swell and burst if placed in distilled water.
- **E.** Distilled water would probably have served the purpose just about as well.

408. (3.00) The high red corpuscle count of the Indians living in the Andes Mountains is most closely associated with which one of the following?

- **A.** More red blood cells are needed to maintain their red skin color.
- **B.** Life is more rigorous in primitive situations than in highly civilized urban areas.
- **C.** The total oxygen content of the air they breathe is lower than in lowland regions.
- **D.** Exposure to frequent insect bites, especially the anopheles mosquito, results in almost continuous antigen-antibody reaction.
- **E.** High red corpuscle count is characteristic of races with high protein diet.

The following is a digest on circulation taken from Harvey.

"The heart is commonly said to be the source and factory of the vital spirits, from which life is given to the different portions of the body, yet that the right ventricle makes spirits is denied—it merely gives nourishment to the lungs. So it is said that the right ventricle of the heart is lacking in fishes (indeed in all animals in which there are no lungs), and that the right ventricle exists for the sake of the lungs.

"The two auricles beat together and so do the two ventricles, so that there are four distinct movements in space, but only two in time. This happens as follows:

"Two sets of movements occur together, one of the auricles, another of the ventricles. These are not simultaneous, but that of auricles precedes that of the rest of the heart. The movement seems to start in the auricles and to spread to the ventricles. This being filled, the heart raises itself, makes its fibers tense, contracts, and beats. By this beat it at once ejects into the arteries the blood received from the auricle; the ventricle sending its blood to the lungs through the vessel called the *vena arteriosa*, but which in structure and function is an artery; the left ventricle sending its blood to the aorta, and to the rest of the body through the arteries.

"Since blood is constantly sent from the right ventricle into the lungs through the pulmonary artery, and likewise constantly is drawn into the left ventricle from the lungs, as is obvious from what has been said and the position of the valves, it cannot do otherwise than flow through continuously. Then I thought of the arrangement and structures of the valves and the rest of the heart. I began to think there was a sort of motion as in a circle. This afterwards I found true, that blood is pushed by the beat of the left ventricle and distributed through the arteries to the whole body, and back through the veins to the vena cava, and then returned from the lungs through the pulmonary vein to the left ventricle.

"Thus it happens in the body by the movement of the blood, all parts are fed and warmed by the more perfect, more spiritous, hotter, and, I might say, more nutritive blood. But in these parts this blood is cooled, thickened, and loses its power, so that it returns to its source, the heart, the inner temple of the body to recover its virtue.

"Here it regains its natural heat and fluidity, its power and vitality, and filled with spirits, is distributed again. All this depends on the motion and beat of the heart.

"Meanwhile I know and state to all that the blood is transmitted sometimes in a larger amount, other times in a smaller, and that the blood circulates sometimes rapidly, sometimes slowly, according to temperament, age, external or internal causes, normal or abnormal factors, sleep, rest, food, exercise, mental condition and such like."

Anatomical Studies on the Motion of the Heart and Blood by William Harvey (1578-1657).

For items 409 - 448, after each item number on the answer sheet, blacken space

- **A.** if the statement is according to Harvey's conception of circulation, but not the present conception.
- **B.** if the statement is according to the present conception of circulation, but not Harvey's conception.
- **C.** if the statement refers to a conception that is common to both.
- **D.** if the statement is not true according to either conception.

409. (4.20) The pulmonary veins carry blood which is rich in carbon dioxide.

410. (4.20) The cells of all tissues are bathed in lymph.

411. (4.20) The human heart contains four chambers.

412. (4.20) The systemic circulation is the flow of blood from the heart to all general body tissues and back to the heart.

413. (4.20) Blood flows through the heart from the left auricle to the right ventricle.

414. (4.20) The pulmonary circulation is the flow of blood from the heart to lungs and back to the heart again.

415. (4.20) The blood carries heat to the different systems of the body.

416. (4.20) The substance hemoglobin is a red pigment with an affinity for oxygen.

417. (4.20) A "blue baby" is one in which the red blood cells (erythrocytes) are not red enough.

418. (4.20) Blood plasma acts as a transporting vehicle for glucose, amino acids, vitamins and hormones.

419. (4.20) Human blood is one of the tissues of the body.

420. (4.20) The lymph nodes function in manufacturing hemoglobin.

421. (4.20) The lymph transports fats in the lacteals of the villi.

422. (4.20) The human heart receives no nervous stimulation.

423. (4.20) The blood obtains its heat from the heart.

424. (4.20) The pulmonary artery conducts blood to the lungs.

425. (4.20) Diastole, or the relaxation phase of the heartbeat, is due to the expansion of the heart.

426. (4.20) The valves of the veins are so placed that they direct the flow of blood toward the heart.

427. (4.20) The blood contains more red blood cells than white blood cells.

428. (4.20) Systole is the contraction phase of the heartbeat.

429. (4.20) The aorta carries blood away from the heart.

430. (4.20) The primary function of the right ventricle is to nourish the lungs.

431. (4.20) The coronary artery supplies blood to the brain.

432. (4.20) The human heart can be considered functionally as two distinct and separate force pumps.

433. (4.20) The white blood cells (leucocytes) are able to ingest bacteria.

434. (4.20) Fats may enter the blood stream by way of the lymph ducts.

435. (4.20) Contraction of the auricles precedes that of the ventricles.

436. (4.20) The capillary bed connects the arteriole with the venule.

437. (4.20) Emotions cause changes in the blood pressure.

438. (4.20) Most persons carry a number of specific antibodies in their plasma.

439. (4.20) Contraction of muscles results in the production or release of the heat; the latter is used to warm the blood.

440. (4.20) The blood while warming the organs is cooled and thickened.

441. (4.20) There is an increase in the circulation during exercise.

442. (4.20) Carbon dioxide diffuses out of the blood into an air sac (alveolus) because its concentration is higher in the blood than in the lumen of the alveolus.

443. (4.20) Temperament is a factor influencing the rate of blood flow.

444. (4.20) Platelets are fragile structures that readily disintegrate to form a substance essential to the clotting process.

445. (4.20) The impulse for each heartbeat originates in a group of cells called the sinus node, located in the wall of the right auricle.

446. (4.20) The right auricle and the right ventricle beat together followed by the left auricle beating with the left ventricle.

447. (4.20) A clot which remains attached to its point of origin and obstructs blood flow is called a thrombus.

448. (4.20) During ventricular contraction, the blood is forced into the pulmonary artery and the aorta.

449. (3.00) Acetylsalicylic acid (the active agent in aspirin), when given to tonsillectomy patients to relieve pain, has the adverse effect of prolonging bleeding by diminishing blood-clotting effectiveness. In connection with which one of the following would the use of such a substance which retards clotting be most advantageous?

A. An appendectomy. **B.** Cancer. **C.** Polio.
D. Coronary thrombosis.
E. Hemorrhage of the lungs.

Read the description of circulation by Descartes and answer the exercises which follow it.

"We know that all movements of the muscles, as also all the senses, depend on the nerves, which resemble small filaments, or little tubes, which all proceed from the brain, and thus contain like it a certain very subtle air or wind which is called the animal spirits. . . . So long as we live there is a continual heat in our heart, which is a species of fire which the blood of the veins there maintains, . . . and this fire is the corporeal principle of all the movements of our members. . . . Its first effect is to dilate (expand) the blood with which the cavities of the heart are filled; that causes this blood, which requires a greater space for its occupation, to pass impetuously from the right cavity into the arterial vein, and from the left cavity into the great artery; then when this dilation (expansion) ceases, new blood immediately enters from the vena cava into the right cavity of the heart, and from the venous artery into the left cavity. . . . The new blood which has entered into the heart is then immediately afterward rarefied (expanded) in the same manner as that which preceded it; and it is just this which causes the pulse, or beating of the heart and arteries; so that this beating repeats itself as often as the new blood enters the heart. It is also just this which gives its motion to the blood, and causes it to flow ceaselessly and very quickly in all the arteries and veins, whereby it carries the heat which it acquires in the heart to all parts of the body, and supplies them with nourishment."

For items 450 - 472, after each item number on the answer sheet, blacken space

- **A.** if the statement agrees with Descartes' conception of circulation, but not with the present conception.
- **B.** if the statement agrees with the present conception of circulation, but is not included in the above account by Descartes.
- **C.** if the statement refers to a conception that is in agreement with both Descartes' conception and the present conception.
- **D.** if the statement is not true according to either conception.

450. The human heart contains four chambers.
(4.20)

451. The systemic circulation is the flow of blood from the heart to all general body tissues and back to the heart.
(4.20)

452. Blood flows through the heart from the left auricle to the right ventricle.
(4.20)

453. The pulmonary circulation is the flow of blood from the heart to lungs and back again to the heart.
(4.20)

454. The coronary artery supplies blood to the brain.
(4.20)

455. The human heart can be considered functionally as two distinct and separate force pumps.
(4.20)

456. The aorta carries blood away from the heart.
(4.20)

457. The blood obtains its heat from the heart.
(4.20)

458. Systole is the contraction phase of the heartbeat.
(4.20)

459. The valves of the veins are so placed that they aid the blood in its flow toward the heart.
(4.20)

460. Diastole, or the relaxation phase of the heartbeat, is due to the expansion of the heart.
(4.20)

461. The pulmonary artery conducts blood to the lungs.
(4.20)

462. The lymph nodes function to manufacture hemoglobin.
(4.20)

463. The lymph collects fats in the lacteals of the villi.
(4.20)

464. The human heart receives nervous stimulation.
(4.20)

465. Human blood is one of the tissues of the body.
(4.20)

466. Blood plasma acts as a transporting vehicle for vitamin and hormones.
(4.20)

467. A "blue baby" is one in which the red blood cells (erythrocytes) are not red enough.
(4.20)

468. The cells of all tissues are bathed in lymph.
(4.20)

469. The blood carries heat to the different systems of the body.
(4.20)

470. The pulmonary veins carry blood which is rich in carbon dioxide.
(4.20)

471. The substance hemoglobin is a red pigment with an affinity for oxygen.
(4.20)

472. Blood in the arteries reaches the veins through capillaries.
(4.20)

Items 473 - 487 involve a critique of the following account of Sir William Harvey's work on circulation.

"The work in which Harvey expounded his new idea of the circulation of the blood was published in 1628 at Frankfurt am Main. . . . After giving an account of the old traditional theories on the subject, in which he sharply brings out their defects, Harvey presents his own observations on the movement of the heart. According to the old theory the walls of the heart were not muscular and the dilatation of the heart was its most important function; by this means the blood was conveyed from the veins into the heart. By careful experiments, of which he gives an account, Harvey found that the heart is muscular and that, on the contrary, its regular contraction is its most important movement, which drives the blood forward—that is, out into the blood vessels—just as it is likewise during this movement that the heart beats against the thorax. In this movement not only the ventricles of the heart take part, but also its vestibule, the significance of which Harvey rightly emphasizes for the first time. He then gives an account of the course of the blood from the right to the left side of the heart through the lungs. With regard to the part played by the lungs and the air in this circulation he has not much to add to the hypotheses of his predecessors. After having thus described the small circulation, Harvey proceeds to a presentation of the blood's movement in the body itself and it is here that he brings out his most daring originality. According to the old theory, food was converted in the liver into blood, which was driven through the veins partly to the heart, in order to receive the *'spiritus vitalis,'* and partly into the body. To this theory Harvey opposes a mathematical calculation; if the human heart contains two ounces of blood and gives sixty-five beats to the minute, then it drives in less than one minute ten pounds of blood out into the body. Such a quantity of blood cannot incessantly arise from the food consumed, but it must be assumed that the same quantity of blood incessantly circulates in the body; it is driven out through the arteries and returns through the veins. Harvey then collects a quantity of evidence in proof of this conclusion from the relation of the arteries and the veins to the body. He investigates the arterial pulse both in normal individuals and in those having calcinated veins; he opens a live serpent and ties up first the vena cava and then the aorta; while the vein is emptied between the heart and the ligature and swells up on the other side, the contrary is true of the aorta. He studies the venous valves in a man's arm, which were discovered by Fabrizio, and shows how they swell below a ligature; he severs a vein and an artery parallel to it and shows that the blood flows from the different ends of the wound. On these and several other grounds, deduced from the study of every possible animal form, he draws the conclusion that the arteries convey the blood from the heart out into the body; there it is transmitted into the ramifications of the veins and flows from these into the principal vein and thence back to the heart. The arterial blood, he considers, provides nourishment for the body, while that of the veins is impure. How the transition between the arterial and venous system takes place he could not explain; the capillary system he was unable to distinguish, . . . and he therefore assumed that some kind of ramified hollows formed the connecting link between the two. Another weak point in his theory was that he could never find a satisfactory explanation of how the components of the food are converted into blood, but he had to be content with the old hypothesis that the liver was the medium in this process. He lived to see the discovery by others of the lymphatic and thoracic ducts, but then he was no longer capable of realizing how well these experiences complemented his own discoveries; he desired to know nothing about them and on this point adhered to the old theory.

"If we compare Harvey's account of the circulation of the blood with the old vascular theory, we find fundamental differences in the two conceptions, both anatomically and physiologically. According to the old theory the heart was not a muscular organ; it dilated purely passively and allowed the blood to enter in order to be provided with 'vital spirit,' this being the primary life-function of the heart, if it were not also, as Aristotle and his followers until Cesalpino held, the center of intelligence. Again, the blood moved of itself owing to the specifically living qualities which the 'spiritus' lent it. Harvey on the other hand, proves that the movement of the blood is due to the purely mechanical function of the heart: the heart's muscular contraction propels the blood out into the blood vessels, through the arteries out into the body, thence back to the heart through the veins, and so farther through the lungs. In this contrast lies, one may say, the great difference between the ancient and the modern biological conception. Even Harvey's way of producing his proofs is purely modern; while Servet still refers back to philosophical speculations and the interpretation of classical authors, Harvey propounds a purely mathematical calculus on the volume of the heart and vascular system and continues to prove his thesis by means of observations and experiments on a number of both higher and lower animal forms. He thus fulfills in the sphere of biology the requirement which his contemporary Bacon laid down as a principle of science: to explain nature by experience based upon observations and experiment. And even Galileo's fundamental principle governing natural research—to measure what can be measured and to make measurable what cannot be measured—is applied to living nature by Harvey for the first time. Galileo also thought that science can only explain how the forces of nature operate; what their innate essential quality is will never be known under any circumstance. In his explanation of the circulation of the blood Harvey does indeed fulfill the first half of this principle; on the other hand, by adhering to the ancient belief in the vital spirits in the blood he remains in his theoretical conceptions entirely on ancient ground."

Erik Nordenskield. *The History of Biology*, Alfred A. Knopf, 1928. pp. 115-117.

473. Harvey's predecessors and contemporaries believed that
(4.20)

- **A.** the blood courses through the body in a circle.
- **B.** the veins pump the blood.
- **C.** the heart "sucks" the blood from the veins.
- **D.** the blood is manufactured in the heart.
- **E.** the blood circulates in response to the force of gravity.

474. At the time Harvey's report was published
(4.20)

- **A.** the microscope had just been perfected by Leeuwenhoek.
- **B.** Schleiden and Schwann had announced the Cell Theory.
- **C.** bacterial causation of tuberculosis had been established by Koch.
- **D.** phenomena not clearly understood were generally attributed to supernatural causation.
- **E.** Pasteur had just announced his treatment for rabies.

475. Which of the following would best characterize Harvey's
(4.20) work?

- **A.** Harvey discovered the mode of circulation of the blood accidentally.
- **B.** Harvey was in complete disagreement with his contemporaries on all life phenomena.
- **C.** Harvey nearly lost his life because of his new theory.
- **D.** Harvey spent a major portion of his life establishing his theory of circulation.
- **E.** Harvey's theory was publicly denounced by the King of England.

476. In Harvey's day most published information about body
(4.20) structure and function was derived from

- **A.** ancient philosophy. **B.** religious writings.
- **C.** uneducated people with limited knowledge.
- **D.** charlatans who profited by superstition then rampant.
- **E.** astrologers.

477. In Harvey's day
(4.20)

- **A.** knowledge of body structure lagged behind knowledge of body functioning.
- **B.** knowledge of body functioning lagged behind knowledge of body structure.
- **C.** most so-called scholars and scientists were very dull and lacking in ingenuity in comparison to present-day scientists and scholars.
- **D.** a scientist, no matter how capable, was obliged to tone down his statements, no matter how accurate and significant they were, or invariably stand to lose his life by beheading.
- **E.** scientists and scholars generally confined themselves to narrow and more specialized fields of investigation than is true among present-day scientists and scholars.

478. How would a scientist in Harvey's day have determined
(4.20) with certainty whether or not the heart is muscular?

- **A.** He could have read what Aristotle had written on this subject.
- **B.** He could have asked some of his colleagues.
- **C.** He could have studied the heart action in dissected live animals.
- **D.** He could have reasoned out an answer from all known data by first setting up an hypothesis, then testing it mentally to determine if it were logical, without reference to any animal specimens.
- **E.** It would have been impossible to answer this question in Harvey's day.

479. Harvey's theory regarding the manner in which the
(4.20) blood passes from the right side of the heart to the left side of the heart

- **A.** was based upon the assumption that there is an interconnecting valve between the right and left ventricles.

B. assumed the presence of a valve joining the right auricle to the left auricle.

C. assumed an open circulatory system in which the blood leaves the right side of the heart through the aorta, passes freely about in the body cavities and re-enters the circulatory system by way of the veins which conduct it to the left side of the heart.

D. was a radical departure from the prevailing conceptions of his day.

E. agreed in the main with the theories of his contemporaries.

480. (4.20) Harvey's working hypothesis, used as a basis for disproving the contemporary misconceptions of the systemic circulation, might have been stated:

A. The blood becomes a self-activating, living entity after it has passed through the heart.

B. Food is converted into blood in the heart.

C. The red blood cells are manufactured in the bone marrow.

D. The blood is circulated through the body as a result of muscular contraction of the heart.

E. The blood is dynamic—it is constantly being subtracted from and added to throughout life.

481. (4.20) Concerning the "spiritus vitalis"

A. Harvey was an objective scientist and considered this theory, held by his contemporaries, as foolish.

B. Harvey had no other explanation, hence he was inclined to accept this theory.

C. present-day scientists no longer speculate as to whether it is vitalism or mechanism which makes the body function.

D. this is a philosophical question which is of no concern to biologists.

E. this term was invented by Harvey to describe aeration of the blood.

482. (4.20) Which of the following steps in Harvey's experiment contributes least to his proof that the blood circulates?

A. Pinching off both vena cavas and the pulmonary veins caused the two auricles to collapse.

B. Individuals with calcinated veins were included among the subjects Harvey observed.

C. Closure of the aorta and pulmonary artery caused the two ventricles to swell.

D. Blocking of any artery caused accumulation of blood in that artery on the side toward the heart.

E. Cutting an artery caused a spurting from only one cut end.

483. (4.20) Harvey was able to postulate the existence of capillaries (though he never saw capillaries) on the basis of all except which one of the following?

A. More blood is pumped through the arteries to the tissues than could possibly be used up by the tissues.

B. The veins receive more blood than can be accounted for on any other basis than a connection with the arteries.

C. The blood which is pumped through arteries to the lungs returns to the heart through veins leading from the lungs.

D. It is possible to drain off the blood of the body by opening any large artery or vein.

E. It was held that the blood moved from the right heart into the left through openings in the partition between the two.

484. (4.20) Harvey's patients, especially those with circulatory disorders, probably

A. placed increased confidence in him as a result of his thoroughgoing research.

B. took pride in having such an eminent man as their attending physician.

C. read eagerly the accounts of his research.

D. sought another physician.

E. died prematurely.

485. (4.20) Which of the following attributes of Harvey or his work is least meritorious?

A. Harvey confined his research to one major problem.

B. Harvey based his conclusions upon experimentation.

C. Harvey was not interested in other scientists' discovery of the lymphatic and thoracic ducts.

D. Harvey published his treatise after nine years of continuous experimentation.

E. The King of England stood by Harvey and retained him as court physician.

486. (4.20) Harvey discovered the fact that the blood circulates by

A. using the method of Aristotle.

B. using the method employed by his own contemporary scientists.

C. using the scientific method which present-day scientists employ.

D. deductive reasoning.

E. sheer chance—he happened upon it quite unexpectedly.

487. (4.20) In deciding to carry through his work on the circulation of the blood, Harvey

A. did the logical thing that anyone else in his circumstances would have done.

B. showed a selfish attitude in seeking personal fame at the sacrifice of his patients' welfare.

C. chose to increase the sum total of human knowledge in preference to material gain and personal comfort.

D. gained the respect of all his colleagues and countrymen before he died.

E. did the medical profession irreparable damage for at least a hundred years.

13. Digestion, Nutrition, Metabolism

DIGESTION, NUTRITION, METABOLISM

1. (1.10) One reason food when swallowed normally does not enter the trachea is that

A. in the trachea, the peristaltic waves travel upward.
B. the air and food passages are separate in the mammal.
C. the vocal cords in the glottis close off the opening.
D. the esophagus has elastic walls.
E. the Adam's apple bobs upward.

2. (1.10) When milk is swallowed and enters the stomach,

A. since it is liquid it passes through the stomach and is acted on only by the enzymes in the intestine.
B. digestion of the double sugars in milk continues briefly until the milk runs through into the intestine where the fat and protein in milk are also acted on by enzymes.
C. the milk is curdled so that it remains in the stomach for pepsin to act on it.
D. an especially rapid enzyme in the gastric juice hydrolyzes the protein in the milk before its runs through into the intestine.
E. it passes immediately through the stomach inasmuch as milk does not require digestion.

3. (1.101) The passage of food from the stomach to the small intestine is regulated by

A. the rate at which food enters the stomach.
B. the degree of acidity of the duodenal contents.
C. the opening and closing of the pyloric valve.
D. the volume of food in the stomach.
E. the homone gastrin.

Items 4 - 13. Place of action

A. large intestine. **B.** liver. **C.** mouth.
D. small intestine. **E.** stomach.

Where do the following enzymes act?

4. (1.10) Amylopsin.

5. (1.10) Enterokinase.

6. (1.10) Erepsin.

7. (1.10) Glycogenase.

8. (1.10) Lactase.

9. (1.10) Lipase.

10. (1.10) Pepsin.

11. (1.10) Ptyalin.

12. (1.10) Rennin.

13. (1.10) Sucrase.

14. (1.10) Digestion is perhaps most aptly defined as

A. the chemical breakdown of large organic food molecules into smaller molecules which are soluble and diffusible.
B. the intake of any kind of food by a living individual.
C. the total physical activity of that system of organs that includes the stomach, esophagus, liver, pancreas, and intestines.
D. the act of eating food, including specifically chewing and swallowing.
E. None of the above.

Directions: For items 15 - 20, blacken the answer space corresponding to the one appropriate portion of the digestive tract from the list below.

KEY

Portions of the Human Digestive Tract

A. Mouth. **B.** Stomach. **C.** Large intestine.
D. Esophagus. **E.** Small intestine.

15. (1.10) Solid food is "thoroughly liquefied" in this organ.

16. (1.10) Digestion is completed in this organ.

17. (1.10) Most of the water is absorbed into blood from the contents of this organ.

18. (1.10) This organ acts chiefly as a passageway for food.

19. (1.10) Digestion begins in this organ.

20. (1.10) Food is propelled in this organ by a complex muscle protruding from its wall.

For items 21 - 25, select the best answer to each of these items from the key list below.

KEY

A. ptyalin. **B.** pepsin. **C.** trypsin.
D. invertase. **E.** steapsin.

21. (1.10) Which of the above enzymes is produced in the mouth?

22. (1.10) Which enzyme acts on sucrose?

23. (1.10) The action of which enzyme results in the production of amino acids?

24. (1.10) Which enzyme requires an acid environment?

25. (1.10) Which enzyme acts on fats?

26. (1.10) An enzyme responsible for the digestion of proteins is

A. maltase. **B.** ptyalin. **C.** lactic acid.
D. steapsin. **E.** trypsin.

27. (1.10) The amino acids are products of the conversion of

A. monosaccharides. **B.** disaccharides.
C. polysaccharides. **D.** glycerol. **E.** polypeptids.

28. (1.10) Bile is secreted by the

A. pancreas. **B.** kidneys. **C.** uriniferous tubules.
D. small intestine. **E.** liver.

29. (1.10) Scurvy may be a result of deficiency in Vitamin

A. A. **B.** B. **C.** C. **D.** D. **E.** E.

30. (1.10) Sugars and nitrates in the presence of certain enzymes may combine in the plant cell to form.

A. amino acids. **B.** cellulose. **C.** fatty acid.
D. starch. **E.** glycogen.

For items 31 - 35 on questions about vitamins, an answer must not be used more than once.

Vitamins:

A. A. **B.** C. **C.** D. **D.** E. **E.** K.

31. (1.10) Which vitamin is directly related to the process of blood clotting?

32. (101) Which is directly related to the process of reproduction in certain animals?

33. (1.10) Which is readily manufactured by the human body?

34. (1.10) Which of the remaining is fat soluble?

35. (1.10) Which of the remaining is water soluble?

36. (1.10) The characteristic of protoplasm to construct new protoplasm from simple materials, and to break down living matter is referred to by the general term

A. anabolism. **B.** osmosis. **C.** catabolism.
D. metabolism. **E.** symbiosis.

37. (1.10) The characteristic of protoplasm to construct new protoplasm from simple materials, to oxidize food materials, and to break down living matter is referred to by the general term

A. anabolism. **B.** osmosis. **C.** catabolism.
D. metabolism. **E.** symbiosis.

38. (1.10) Digestion serves to

A. convert small food particles into larger food particles.
B. convert simpler foods into more complex foods.
C. convert larger non-diffusible molecules into smaller diffusible ones.
D. convert foods into enzymes needed for digestion.
E. regulate the rate of metabolism.

39. (1.10) Metabolism is

A. energy releasing activity in a cell.
B. reproduction of a cell. **C.** growth of a cell.
D. exchange of materials in a cell.
E. the total of all chemical and physical changes occurring in protoplasm.

40. (1.10) Gastric juice contains

A. a starch-splitting enzyme and secretin.
B. a protein-splitting enzyme and hydrochloric acid.
C. a fat-splitting enzyme.
D. all of the above substances.
E. none of the above substances.

41. (1.10) The chemical element which is always present in protein but never in fats and carbohydrates is

A. carbon. **B.** hydrogen. **C.** oxygen.
D. nitrogen. **E.** sodium.

Item 42 deleted.

43. (1.10) Insulin is present in the

A. pancreatic juice. **B.** pancreas.
C. thyroid. **D.** adrenal glands.

44. (1.10) Chemical agents produced by living things and having the capacity to speed up or slow down chemical reactions in the body are known as

A. organic acids. **B.** inorganic catalysts.
C. agglutinins. **D.** enzymes. **E.** precipitins.

45. (1.10) The following enzymes are found in the pancreas

A. pepsin. **B.** lipase. **C.** sucrase. **D.** lactase.

46. (1.10) Common white flour is obtained from that part of the wheat seed called

A. coleoptile. **B.** epithelium. **C.** embryo.
D. germ. **E.** endosperm.

47. (1.10) Glycogen is mainly stored in

A. liver and muscle. **B.** cartilage and bone.
C. fat tissue. **D.** villi.

48. (1.10) Which one of the following enzymes is always present in the mouth?

A. lactase. **B.** amylopsin. **C.** maltase.
D. none of these.

49. (1.10) Glycogen is a

A. monosaccharide. **B.** nonsaccharide.
C. disaccharide. **D.** polysaccharide.

50. (1.10) The following enzyme digests carbohydrates

A. amylopsin. **B.** trypsin. **C.** lipase.
D. pepsin.

51. (1.10) The following secretion aids in the digestion of fats

A. bile. **B.** trypsin. **C.** pepsin.
D. enterokinase.

52. (1.10) Secretin stimulates the

A. salivary glands. **B.** stomach. **C.** adrenals.
D. pancreas.

53. (1.10) Villi have the following function:

A. Secretion of adrenalin.
B. Secretion of intestinal juice.
C. Increase absorption surface.
D. None of these.

54. (1.10) Which of the following enzymes function best in an acid medium?

A. trypsin. **B.** amylopsin. **C.** pepsin.
D. enterokinase.

55. (1.10) Proteins are primarily used by the body to form.

A. carbohydrates. **B.** fats. **C.** protoplasm.
D. none of these.

56. (1.10) Deamination of proteins occurs mainly in

A. the small intestine. **B.** the pancreas.
C. the spleen. **D.** the liver.

57. (1.10) Which of the following vitamins may be readily manufactured in our bodies?
A. A. **B.** B. **C.** C. **D.** D.

58. (1.10) Calcium is especially important in the diet for which of the following?

A. Production of hemoglobin.
B. Production of bone and teeth.
C. Formation of red blood cells.
D. Formation of white blood cells.

59. (1.10) Lack of iodine is often related to which of the following diseases?

A. Beriberi. **B.** Scurvy **C.** Rickets.
D. Thyroid disease.

60. (1.10) Which of the following is directly related to the process of reproduction?

A. Vitamin K. **B.** Vitamin B_1.
C. Vitamin E. **D.** Vitamin G (B_2).

61. (1.10) Which of the following is directly related to the process of blood clotting?

A. Vitamin D. **B.** Vitamin C.
C. Vitamin K. **D.** Vitamin A.

62. (1.10) Four grams of carbohydrates give

A. 37.2 calories. **B.** 25.3 calories.
C. 16.4 calories. **D.** none of the above.

63. (1.10) The water content of a normal man is approximately

A. 10%. **B.** 25%. **C.** 60 to 65%. **D.** 95%.

64. (1.10) Large complex molecules are subdivided chemically into smaller, simpler components in digestion by the process known as

A. synthesis. **B.** condensation. **C.** hydrolysis.
D. symbiosis. **D.** plasmolysis.

65. (1.10) Raw (uncooked) starches are digested to simple sugars in the

A. mouth. **B.** stomach. **C.** small intestine.
D. large intestine. **E.** pancreas.

66. (1.10) Ptyalin (in man) is included in the secretion of the

A. salivary gland. **B.** pancreas. **C.** liver.
D. stomach. **E.** small intestine.

67. (1.10) The effect of ptyalin is to

A. increase the tonus of the involuntary muscles in emergency situations.
B. digest starch. **C.** regulate the metabolic rate.
D. initiate the growth of secondary sex characters.
E. prevent tetany (muscle twitching).

68. (1.10) The reaction of the digestive fluids secreted into the small intestine is

A. acid. **B.** alkaline. **C.** neutral.
D. variable. **E.** indeterminable.

69. (1.10) The products of fat digestion are absorbed by the

A. capillaries in the villi. **B.** lacteals in the villi.
C. capillaries in the walls of the stomach.
D. gall bladder.
E. finger-like appendage protruding from the caecum.

70. (1.10) The largest gland in man's body is the

A. thyroid. **B.** pituitary. **C.** liver.
D. pancreas. **E.** kidney.

71. (1.10) An end product of fat *digestion* is

A. glycogen. **B.** galactose. **C.** glucose.
D. glycerol. **E.** fructose.

72. (1.10) Food is moved along through the intestine by a wave-like motion known as

A. oscillation. **B.** fluctuation. **C.** permutation.
D. permeation. **E.** peristalsis.

73. (1.10) Besides food absorption, another function of the villi is

A. to mix the food in the intestine.
B. to manufacture enzymes.
C. to absorb nitrogenous waste products and toxins.
D. to inactivate bacteria which tend to multiply in the intestine.
E. to discharge adrenalin in emergency situations.

74. (1.10) The chief function of roughage is

A. to stimulate peristalsis.
B. to provide a reserve supply of concentrated food for emergency use by the body.
C. to build muscle tissue.
D. to provide certain vitamins which tend to be deficient in the diet.
E. to provide a quick source of energy.

75. (1.10) Which of the following is the richest source of vitamin D?

A. Citrus fruits.
B. Green leafy vegetables (such as lettuce).
C. Fish oils.
D. Root vegetables (carrots, turnips, etc.).
E. Lean beef.

76. (1.10) Which vitamin should children eat in order to prevent rickets?

A. Vitamin A. **B.** Vitamin B. **C.** Vitamin C.
D. Vitamin D. **E.** Vitamin E.

77. (1.10) The gall bladder stores and discharges a product which

A. regulates the metabolism of sugar in the body.
B. is a metabolic waste product called urine.
C. digests protein foods.
D. facilitates digestion of protein foods.
E. breaks fat globules into smaller particles.

78. (1.10) Riboflavin is

A. a kind of protein. **B.** a vitamin.
C. a hormone. **D.** a kind of fat. **E.** an enzyme.

79. (1.10) The pancreas will release its digestive fluid into the pancreatic duct leading to the small intestine when stimulated by

A. nerve impulses from the autonomic nervous system.
B. hydrochloric acid from the digestive juice in the stomach.
C. secretin in the bloodstream.
D. the sensation of bulk and pressure of food entering the intestine.
E. nerve impulses from the brain.

80. (1.10) The best description of the function of bile is that bile

A. aids in the break-up (emulsification) of fat particles into smaller globules to facilitate enzymatic action.
B. is an enzyme which digests fats in the small intestine.
C. is an enzyme which completes the digestion of those proteins which were only partially digested in the stomach.

D. digests carbohydrates which escaped digestion by the saliva.
E. is an endocrine secretion which regulates carbohydrate metabolism in the body.

81. (1.10) An operation which impairs the flow of bile would directly

A. slow the production of insulin.
B. impair the body's utilization of vitamin C.
C. retard fat digestion.
D. inhibit voluntary muscular reactions.
E. inhibit starch digestion.

82. (1.10) A deficiency disease characterized by soft, deformed bones is

A. beri-beri. **B.** pellagra. **C.** scurvy.
D. rickets. **E.** xerophthalmia.

83. (1.10) The large molecules of protein, carbohydrates, and fats are broken down into simpler substances in the digestive processes largely by means of

A. hydrolysis. **B.** condensation. **C.** synthesis.
D. plasmolysis. **E.** agglutination.

84. (1.10) Vitamin D is most abundant in

A. Spinach and other green leafy vegetables.
B. carrots and similar root vegetables.
C. lean meat. **D.** fish oils.
E. oranges and grapefruit.

85. (1.10) The process of digestion in man is

A. limited strictly to the activity of the digestive tract.
B. the burning up of "food" in each body cell.
C. usually considered as the chemical breakdown of food in the alimentary canal.
D. the absorption of food from the digestive tract.
E. the assimilation of food in each and every living cell.

86. (1.10) The chief substance absorbed from the contents of the large intestine is:

A. simple sugar. **B.** water. **C.** amino acids.
D. fatty acids and glycerin. **E.** glycogen.

87. (1.10) In man the organs that secrete proteases are

A. salivary glands and liver.
B. stomach, pancreas, and small intestine.
C. salivary glands, liver, large intestine.
D. stomach, liver, and large intestine.
E. stomach, small intestine, large intestine.

88. (1.10) The most important fat-splitting enzyme is secreted by the

A. salivary glands. **B.** stomach. **C.** liver.
D. pancreas. **E.** small intestine.

89. (1.10) Bile is important because it

A. acts as a hormone that stimulates the pancreas.
B. has an enzyme that acts on fats.
C. emulsifies fats.
D. provides a suitable medium for the action of pepsin.
E. has a starch-splitting enzyme.

90. (1.10) Villi function in

A. moving food along the small intestine.
B. secreting a fat-splitting enzyme.
C. secreting hormones that stimulate the stomach.
D. increasing the surface area of the small intestine.
E. absorbing most of the water from the intestine.

91. (1.10) Excess amino acids in the body are

A. stored as proteins in the liver.
B. deaminized in the liver.
C. eliminated as such by the kidneys.
D. eliminated by the large intestine.
E. converted into proteins stored in the fat depots.

92. (1.10) Gastric protease acts best in

A. an alkaline environment.
B. neutral environment. **C.** acid environment.
D. in any environment. **E.** a waterless environment.

93. (1.10) In this organ, hydrochloric acid is formed.

A. Mouth cavity. **B.** Pharynx. **C.** Esophagus.
D. Stomach. **E.** Small intestine.

94. (1.10) Most of the water in the digestive tract is absorbed by the

A. pharynx. **B.** esophagus. **C.** stomach.
D. small intestine. **E.** large intestine.

95. (1.10) Bile normally

A. passes directly to the small intestine.
B. is temporarily stored in the pancreas.
C. is all re-absorbed by the small intestine.
D. provides an alkaline medium required for most efficient action of pancreatic enzymes.
E. is re-absorbed, passes into the blood stream, and then activates the pancreas.

96. (1.10) The end products of protein digestion are

A. amino acids. **B.** fatty acids and glycerin.
C. simple sugars, nitrate and sulphate salts.
D. double sugars and amines.
E. organic acids and amines.

97. (1.10) Vitamins function as

A. sources of heat. **B.** body regulators.
C. sources of new protoplasm.
D. sources of energy. **E.** minerals.

98. (1.10) Night blindness results from a mild deficiency of

A. Vitamin A. **B.** Vitamin B. **C.** Vitamin C.
D. Vitamin D. **E.** Vitamin K.

99. (1.10) Citrus foods are good sources of

A. Vitamin A. **B.** Vitamin B_1. **C.** Vitamin C.
D. Vitamin D. **E.** Vitamin E.

100. (1.10) Rickets results from a deficiency of

A. Vitamin A. **B.** Vitamin B_1. **C.** Vitamin C.
D. Vitamin D. **E.** Vitamin E.

101. (1.10) Normal calcification of bone results from a supply of

A. Vitamin A. **B.** Vitamin B_1. **C.** Vitamin C.
D. Vitamin D. **E.** Vitamin E.

102. (1.10) Carbohydrates and fats are utilized by the body as sources of

A. energy. **B.** new protoplasm.
C. mineral content. **D.** body-building materials.
E. vitamins.

103. (1.10) Proteins are sources of

A. energy. **B.** calcium and phosphorus.
C. minerals. **D.** body-building materials.
E. vitamins.

104. (1.10) Mineral salts function

A. in maintaining body temperature.
B. in maintaining a proper environment for body cells.
C. in building new protoplasm.
D. in providing heat. **E.** in providing energy.

105. (1.10) The body uses iron

A. for proper tooth and bone construction.
B. for the development of brain tissue.
C. to prevent excess loss of salts during sweating.
D. to synthesize vitamins.
E. to maintain a good supply of hemoglobin in the blood.

106. (1.10) Calcium and phosphorus are utilized for

A. prevention of anemia.
B. maintenance of the blood stream in proper condition.
C. proper bone and tooth construction.
D. digestion of certain food materials.
E. storage of carbohydrates.

107. (1.10) Constipation is

A. the too rapid movement of materials through the colon, resulting in watery stools.
B. commonly known as dyspepsia and is a specific ailment of the digestive tract.
C. due to too much bulk foods which decrease the muscle tension of the digestive tract.
D. the retention of fecal material in the colon with accompanying drying of fecal material by absorption of some water from it.

108. (1.10) Pyorrhea is a disease of the teeth characterized by

A. tooth abcesses.
B. irregular alignment of permanent teeth.
C. destruction of pulp cavity.
D. pus formation between the teeth and gum with a gradual disintegration of jaw bone.
E. inflammation of the mouth lining.

109. (1.10) The pulp of a tooth consists of

A. muscle and blood vessels.
B. nerves and muscles.
C. nerves and blood vessels.
D. blood and undigested food materials.
E. muscles, lymph, connective tissue.

110. (1.10) Enzymes are

A. substances which are taken into the body along with food.
B. organic catalysts which bring about the chemical reactions which take place in the body.
C. antibodies which enable the body to resist disease.

111. (1.10) Which of the following is *not* a function of the liver?

A. Storage of carbohydrates in the form of glycogen.
B. Break-up of worn-out red blood cells.
C. Secretion of a digestive juice containing enzymes for fat digestion.
D. Helping to trap invading microorganisms by the fixed phagocytes in the walls of its capillaries.

112. (1.10) Which one of the following is conducted from the digestive tract by the lymphatic system?

A. Hydrochloric acid. **B.** Amino acid.
C. Glycerol. **D.** Glucose. **E.** None of these.

113. (1.10) What is the role of vitamins in metabolism?

A. They supply energy.
B. They are known to be beneficial but their function is unknown.
C. They constitute the bulk of the raw materials which, when deposited in bones and teeth, give these structures hardness.
D. They constitute the bulk of the raw materials from which protoplasm is built.
E. They function in regulating certain reactions essential to life.

True-False

114. (1.10) The large intestine is also known as the colon.

True-False

115. (1.10) An enzyme is an organic catalyst.

True-False

116. (1.10) Lipase is a starch splitting enzyme.

117. (1.10) What role is played by bile in the digestive process?

A. It is an enzyme which converts fat molecules into simpler molecules.
B. It increases the number of fat particles and hence their total surface area.
C. It releases the energy stored in fats, making it available to the body.
D. Bile does all three of the above.
E. Bile does none of the first three above.

118. (1.10) What is meant by digestion?

A. The transformation of complex organic food molecules into simpler ones that can be absorbed.
B. The building up of body tissues from food materials that have passed through the alimentary tract.
C. The release of energy from food materials in the body.
D. All of the above. **E.** None of the above.

119. (1.10) Digestion which occurs in the stomach is

A. intracellular digestion.
B. a form of metabolic activity.
C. a process whereby energy is released.
D. extracellular digestion. **E.** none of the above.

For items 120 - 126, select from the key list below the *one* most appropriate or most closely related item.

KEY

A. hormones **B.** vitamins **C.** proteins
D. fats **E.** enzymes

120. (1.10) Thiamin chloride.

121. (1.10) Inactive storage substances.

122. (1.10) Formed from amino-acids.

123. (1.10) Expedite chemical reactions (catalysts).

124. (1.10) Agent of chemical coordination.

125. (1.10) Necessary in digestion but not changed in the process.

126. (1.10) Insulin.

127. (1.10) All except which one of the following are end products of digestion?

A. Glucose. **B.** Sucrose. **C.** Fatty acids.
D. Glycerol. **E.** Amino acids.

128. (1.10) A calorie is the amount of heat

A. required to raise the temperature of one gram of water one degree Fahrenheit.
B. necessary to raise the temperature of one quart of water one degree Centigrade.
C. required to raise the temperature of one gram of water one degree Centigrade.
D. given off when one Kilogram of water cools one degree Centigrade.
E. necessary to raise the temperature of one quart of water one degree Fahrenheit.

129. (1.10) The large intestine accomplishes primarily which one of the following?

A. Absorption of digested protein.
B. Secretion of insulin. **C.** Concentration of urine.
D. Conservation of water. **E.** Emulsification of fats.

130. (1.10) Which of the following would be regarded as a function of minerals in human metabolism?

A. Synthesis of carbohydrates.
B. Prevention of sterility.
C. Provision of a supply of reserve energy.
D. Regulation of the life processes of the cells.
E. Prevention of degenerative diseases, such as beriberi and scurvy.

131. (1.10) Which of the following hormones insures that an adequate supply of enzymes is present in the small intestine at the time food is arriving there to be digested?

A. Secretin. **B.** Pituitrin. **C.** Theelin.
D. Insulin. **E.** Adrenalin.

132. (1.10) Glycerol is absorbed from the small intestine by the

A. capillaries. **B.** lacteals. **C.** pyloris.
D. spleen. **E.** intestinal caecum.

133. (1.10) Cod liver oil is rich in

A. vitamin A. **B.** vitamin B. **C.** vitamin D.
D. two of the above vitamins.
E. all three of the above vitamins.

134. (1.10) The end product(s) of protein *metabolism* is (are)

A. amino acids. **B.** urea. **C.** glucose.
D. glycogen. **E.** glycerol.

For items 135 - 140, select from the key the name of the vitamin which will alleviate the described condition and mark the corresponding answer space.

KEY

A. Vitamin A. **B.** Vitamin B. **C.** Vitamin C.
D. Vitamin D. **E.** Vitamin K.

135. (1.10) Slow coagulation of the blood.

136. (1.10) Deformation of the bones in infants.

137. (1.10) Stiffness in muscles afflicted with neuritic pains.

138. (1.10) Night blindness.

139. (1.10) Dryness and opaqueness of the cornea of the eye.

140. (1.10) Swelling and hemorrhage of the gums and mucous tissues.

For items 141 - 148, select from the key the word which designates the category to which the substance named in each item belongs and mark the corresponding answer space.

KEY

A. Carbohydrate. **B.** Fat. **C.** Protein.
D. Vitamin. **E.** Inorganic food material.

141. (1.10) Cellulose.

142. (1.10) Ascorbic acid.

143. (1.10) Lactose.

144. (1.10) $C_{18}H_{36}O_2$

145. (1.10) Sodium chloride.

146. (1.10) $(C_6H_{10}O_5)$ n.

147. (1.10) Found in considerable quantities in lean meat.

148. (1.10) Formed by combination of amino acids.

149. (1.10) The greatest amount of energy per unit weight would be supplied to the body by which of the following foods?

A. Lean beef steak. **B.** Potatoes. **C.** Butter.
D. Spinach. **E.** Eggs.

150. (1.10) Cooking of foods lowers the value of their

A. proteins. **B.** carbohydrates. **C.** calories.
D. fats. **E.** vitamins.

151. (1.10) Amino acids carried in the blood stream are ultimately utilized in the

A. body cells. **B.** kidneys. **C.** lungs.
D. alimentary tract. **E.** aorta.

152. When butter is digested, one principal end product of
(1.10) digestion is

A. glycogen. **B.** lymph. **C.** glycerol.
D. urea. **E.** a monosaccharide.

153. A person was given a meal of glucose, salt, protein and
(1.20) water. How many foods were digested?

A. None. **B.** One. **C.** Two. **D.** Three.
E. Four.

For items 154 - 159, select from the key the most appropriate term and mark the corresponding answer space.

KEY

A. Mouth **B.** Esophagus **C.** Stomach
D. Small intestine **E.** Large intestine

154. The first action on foods by protein splitting enzymes
(1.20) will occur in this organ.

155. Two of the above organs produce no digestive enzymes.
(1.20) In which one of these two is there more enzyme action normally occurring?

156. Carbohydrate foods are acted upon by enzymes pro-
(1.20) duced in two of these organs but this organ also contributes mucin to the food material.

157. This organ contributes enzymes from its wall which act
(1.20) best upon proteins in an alkaline medium.

158. The functioning of this organ in the digestion of foods is
(1.20) partially dependent upon the function of the liver.

159. The first place along the alimentary tract that the food
(1.20) encounters peristalsis is in this organ.

160. The function of bile in the digestive process is
(1.20)

A. similar to that of enzymes.
B. similar to the action of soap in an oil-water mixture.
C. purely chemical and requires no catalyst or enzyme.
D. to increase the effect of gastric enzymes.
E. to make the initial changes in complex proteins.

Below are given a number of statements concerning foods, chemical fluids, enzymes, and structures having to do with the digestion of food in man. The number on each blank refers to the number of the question to be answered on the answer sheet. If the term to fill in the blank refers to a food, chemical fluid, enzyme, or structure, look for it in the list so headed, and blacken the appropriate lettered space on the answer sheet. Read each sentence completely before selecting the best terms to fill the blanks.

Foods
A. Fats
B. Sugar
C. Glycogen
D. Proteins
E. Starch

Chemical Fluids
A. Bile
B. Saliva
C. Lymph
D. Hydrochloric Acid
E. Pancreatic Juice

Enzymes
A. Gastric Protease
B. Intestinal Protease
C. Salivary Amylase
D. Pancreatic Amylase
E. Lipase

Structures
A. Liver
B. Pancreas
C. Villi
D. Esophagus
E. Pharynx

Food in the mouth is mixed during mastication with a viscous fluid called **161.** This fluid contains an enzyme **162** that changes insoluble **163** to a soluble form of **164.** Upon being swallowed the food mass passes through the **165** which is the common passage for food and air before entering the **166** that carries it to the stomach. An enzyme in the stomach acts upon nitrogen-containing food called **167.** This enzyme is a **168** which requires activation by the chemical compound **169.** From the stomach the food passes into the small intestines where it is mixed with a juice secreted by the liver called **170.** This juice is essential to the digestion of **171.** Three important enzymes are here added to the food in the secretion of another gland lying outside the tract called the **172.** While moving along the intestine, chemical changes are occurring. Among the substances now present are amino acids which are the final products of the digestion of **173** and fatty acids and glycerol derived from the breakdown of **174.** The absorptive surface of the intestinal wall is increased by the large number of tiny projections called **175.** Some of the soluble products of digestion pass through the thin mucous membrane of the villus wall into the blood which carries them to the large gland, the **176.** Here soluble sugars may be removed from the blood and deposited as insoluble **177,** a starch. Most of the **178** do not enter the blood directly, but enter the **179** for transport to the blood stream.
(All of the above items are classified as 1.20)

For items 180 - 187, after the number on the answer sheet which corresponds to that of each of the following paired items, blacken space

A. if increase in the first of the things referred to is accompanied by increase in the second.
B. if increase in the first of the things referred to is accompanied by decrease in the second.
C. if neither of the above relationships pertain to the given pair of items.

180. In general, size of molecules of dissolved substance in
(1.20) a solution.
Rate at which the molecules will diffuse through a membrane.

181. Solubility of molecules in fat.
(1.20) Rate at which the molecules will enter cells through their plasma membranes.

182. The amount of a given substance changed to another
(1.20) substance as a result of enzyme action.
The amount of change taking place in the enzyme itself.

183. Thickness of layer of fat under the skin.
(1.20) Ease with which excess heat leaves the body.

184. Size of molecules of dissolved substance in the blood
(1.20) stream.
Ease with which these molecules will filter through capillary walls.

185. Rate at which anabolism is occurring in an organism.
(1.20) Rate at which the organism is growing.

186. Amount of differentiation and specialization of cells.
(1.20) In general, the size of the organism.

[illegible]

187. Rate at which carbon dioxide and other waste materials
(1.20) diffuse out of a cell.
Rate at which catabolism is occurring in the cell.

Items 188 - 204 refer to man. After each item number on the answer sheet, blacken space

A. if the item refers to gastric juice.
B. if the item refers to bile.
C. if the item refers to pancreatic juice.
D. if the item refers to more than one of the above.
E. if the item refers to none of the above.

188. It contains no enzymes.
(1.20)

189. Its flow is stimulated by secretin.
(1.20)

190. It is secreted by glands in the stomach.
(1.20)

191. It contains the most important enzyme for the digestion of fat.
(1.20)

192. One of its components is hydrochloric acid.
(1.20)

193. It is secreted by the liver.
(1.20)

194. It contains enzymes which act on double sugars.
(1.20)

195. It is stored in the gall bladder.
(1.20)

196. It contains an enzyme for the digestion of starch.
(1.20)

197. Its secretion is stimulated by a hormone.
(1.20)

198. Its secretion is stimulated by a nerve impulse.
(1.20)

199. One of its components stimulates the production of secretin.
(1.20)

200. It contains protease.
(1.20)

201. It is secreted by glands in the intestine.
(1.20)

202. Its enzymes act best in an alkaline medium.
(1.20)

203. One of its functions is the emulsification of fat.
(1.20)

204. Its enzymes act best in an acid medium.
(1.20)

As blood passes through capillaries in various organs, structures, or tissues of the body it acquires certain substances and loses others. Some substances in the blood do not increase or decrease as the blood passes through certain organs, structures, or tissues. After each item number on the answer sheet, blacken space

A. if this substance increases *in the blood* as the blood passes through the organ, structure, or tissue named.
B. if this substance decreases *in the blood* as the blood passes through the organ, structure, or tissue named.
C. if this substance remains constant *in the blood,* or is not found in the blood passing through the organ, structure, or tissue named.

(Think of heat as a substance and of the substances named with reference to being in the blood, not with reference to the cells of the organs, structures, or tissues named and recall that glycogen is the form in which carbohydrate is stored in the liver.)

The blood in the capillaries of a *muscle* during exercise.	The blood in the capillaries of the villi during the digestion and absorption of a meal.
205. Glucose. (1.20)	**210.** Glucose. (1.20)
206. Heat. (1.20)	**211.** Glycogen. (1.20)
207. Carbon dioxide. (1.20)	**212.** Amino acids. (1.20)
208. Lactic acid. (1.20)	**213.** Oxygen. (1.20)
209. Oxygen. (1.20)	

The blood in the capillaries of the *pancreas* during digestion of a meal.	The blood in capillaries around the *alveoli* of the *lungs.*
214. Hydrochloric acid. (1.20)	**218.** Carbon dioxide. (1.20)
215. Amylase. (1.20)	**219.** Nitrogen. (1.20)
216. Insulin. (1.20)	**220.** Oxygen. (1.20)
217. Secretin. (1.20)	

221. The *fundamental* similarity in digestion whether occurring in plants or in one-celled or many celled animals is
(1.20)

A. the intracellular nature of the process.
B. the synthesis of complex compounds from simpler ones.
C. the formation of soluble compounds as a result of enzyme action.
D. a reversal of the process of photosynthesis resulting in a release of energy.
E. the diffusion of soluble substances through membranes.

222. Digestion in hydra and planaria differs from digestion in earthworms in that digestion in hydra and planaria
(1.20)

A. is both intracellular and extracellular.
B. is entirely intracellular.
C. occurs in a body cavity called a coelom.
D. occurs only in a gastro-vascular cavity.
E. does not involve the functioning of the same types of enzymes.

223. The absorption of the products of fat digestion differs from that of other products of digestion, in that the products of fat digestion
(1.20)

A. are carried by the portal vein to the liver.
B. are not absorbed until the large intestine is reached.
C. usually enter the lymph ducts of the villi and, carried by the lymph, pass through the thoracic duct into the blood.
D. enter the lymph ducts of the villi and are carried to all parts of the body in the lymph.
E. are changed to fatty acids and glycerin as they enter the lymph ducts in the villi.

224. The most important enzyme in gastric juice acts on
(1.20)

A. starches in an acid environment.
B. proteins in an alkaline environment.
C. proteins in an acid environment.
D. fats in an alkaline environment.
E. none of the above.

225. Protein is converted to carbohydrate and ammonia, and
(1.20) ammonia is changed to urea in

A. the liver mainly.
B. the liver and kidneys successively.
C. the kidneys alone. **D.** cells all over the body.

226. Which of the following statements is true of secretin?
(1.20)

A. It is carried by the blood to the pancreas.
B. Hydrochloric acid stimulates its production.
C. It stimulates the secretion of enzymes essential to the digestion of fats, carbohydrates, and proteins.
D. It is produced by certain endocrine glands.
E. Each of the above statements is true of secretin.

Each of the following items (227 - 235) begins by naming some substance and giving its location. After the item number on the answer sheet, blacken the *one* lettered space which designates the structure or organ the substance will *next* enter, or the substance it will *next* be changed into.

227. Water in the cortical cells of the root of a plant:
(1.20)

A. bark. **B.** xylem. **C.** phloem. **D.** coelom.
E. pith.

228. Starch in the leaves of plants at night:
(1.20)

A. glycogen. **B.** fat. **C.** protein.
D. amino acid. **E.** glucose.

229. Fatty acid and glycerin in any part of a plant:
(1.20)

A. double sugar. **B.** protein. **C.** amino acid.
D. fat. **E.** starch.

230. Amino acids in any part of a plant:
(1.20)

A. double sugar. **B.** protein. **C.** glucose.
D. fat. **E.** starch.

231. Excess glucose in leaf of green plant:
(1.20)

A. root. **B.** xylem. **C.** phloem. **D.** coelom.
E. pith.

232. Excess bile produced in the liver:
(1.20)

A. stomach. **B.** pancreas. **C.** gall bladder.
D. large intestine. **E.** spleen.

233. Fat in the presence of bile:
(1.20)

A. glycerin. **B.** fatty acid.
C fatty acid and glycerin. **D.** amino acid.
E. emulsified fat.

234. Ammonia compounds, derived from the breakdown of
(1.20) proteins carried by the blood into the liver:

A. urea. **B.** fatty acid. **C.** amino acid.
D. glycogen. **E.** protein.

235. Fat within the wall of a villus:
(1.20)

A. vein. **B.** artery. **C.** epithelium.
D. lymph duct. **E.** capillary.

236. Which of the following organs is not associated with
(1.20) the physical changes which food undergoes during digestion?

A. Esophagus. **B.** Hard palate.
C. A canine tooth. **D.** Duodenum. **E.** Larynx.

237. Proteins are organic compounds present in protoplasm
(1.20) which are

A. important in maintaining the balance between acids and bases in the cell.
B. necessary for the release of energy.
C. needed for the construction of new protoplasm.
D. generally useful in promoting chemical changes without being appreciably used up themselves.

238. Amino acids carried in the blood stream are ultimately
(1.20) utilized in the

A. body cells. **B.** kidneys. **C.** lungs.
D. alimentary tract. **E.** aorta.

239. When proteins are completely digested they are
(1.20)

A. transformed into amino acids.
B. converted to simple sugars.
C. transformed into glycerin and fatty acids.
D. converted to carbon dioxide and water.
E. transformed to urea and sugar.

240. The pancreas is stimulated to secrete its digestive juice
(1.20) by

A. secretin originating in the liver.
B. secretin originating in the duodenum.
C. secretin originating in the stomach.
D. secretions of the salivary glands. **E.** the bile.

241. The products of carbohydrate and protein digestion
(1.20) pass into

A. lymphatic vessels and then to all parts of the body.
B. lymphatic vessels and then to the liver.
C. the portal vein and then to the liver.
D. the portal vein and then to the pancreas.
E. the portal vein and then to the gall bladder.

242. In the absence of bile,
(1.20)

A. there is less fat to be digested.
B. the surface area at which the fat-splitting enzyme can act is much smaller.
C. the fat-splitting enzyme is inactive due to the lack of its prosthetic group.
D. there is no fat-splitting enzyme.
E. the absorption of all classes of foodstuffs is impaired.

Items 243 - 252, kinds of enzymes:

A. amylolytic (carbohydrate-splitting).
B. coagulating. **C.** lipolytic (fat-splitting).
D. proteolytic (protein-splitting).

To which of the above groups do the following belong?

243. Amylopsin.
(1.20)

244. Erepsin.
(1.20)

245. Lactase.
(1.20)

246. Lipase.
(1.20)

247. Maltase.
(1.20)

248. Pepsin.
(1.20)

249. Ptyalin.
(1.20)

250. Rennin.
(1.20)

251. Sucrase.
(1.20)

252. Trypsin.
(1.20)

253. The amount of urea produced by the dissimilation of
(1.20) fats and carbohydrates is

A. greater than **B.** less than
C. same as the amount produced by the dissimilation of proteins.

254. The concentration of secretin in the hepatic portal vein
(1.20) before the discharge of the contents of the stomach into the small intestine is

A. greater than B. less than
C. same as the concentration of secretin in the same vessel after the discharge.

255. Which of the following conversions is least likely to
(1.20) occur in the human body?

A. Carbohydrates to proteins.
B. Carbohydrates to fats.
C. Fats to carbohydrates.
D. Proteins to carbohydrates. E. Proteins to fats.

256. The amount of urea formed in the liver is
(1.20)

A. greater than B. less than
C. same as the amount formed by the kidney.

257. The amount of storage of proteins in the human body is
(1.20)

A. greater than B. less than
C. same as the storage of carbohydrates in the human body.

Items 258 - 267. Many of the processes which occur within plants and within animals are similar, while some are peculiar to each.

Directions: For each of the following processes, or characterizations of processes, blacken answer space

A. if it occurs within higher *plants* but not higher animals.
B. if it occurs within higher *animals* but not higher plants.
C. if it occurs within *all higher plants* and *all higher animals.*
D. if it occurs within *some higher plants* and *some higher animals.*
E. if it occurs in neither.

258. Reserve carbohydrate is stored in the form of starch.
(1.20)

259. The protoplasm of each cell secretes a protein covering
(1.20) which gives mechanical protection to the cell.

260. Proteins are synthesized only with the assistance of
(1.20) intracellular enzymes.

261. Glucose can be synthesized entirely from inorganic mole-
(1.20) cules obtained from the external environment.

262. Energy is used to build greater concentrations of certain
(1.20) substances within cells than outside cells.

263. Substances are transported from one to another region
(1.20) within the organism by fluid flow.

264. Some cells secrete digestive enzymes which act outside
(1.20) the cells.

265. Photosynthesis itself supplies adequate energy for the
(1.20) needs of the organism so that the process of respiration is absent.

266. The role of certain specialized cells is to support the
(1.20) organism against the force of gravity.

267. Dehydration of the organism is prevented partly by the
(1.20) smallness of the openings through which air can pass from the environment to the surface at which gaseous exchange takes place.

268. The most conclusive test for the presence of a particular
(1.20) enzyme in a protoplasmic extract is

A. its inactivation by high temperatures.
B. the type of vitamin used as a prosthetic group.
C. the presence of nitrogen in its molecular composition.
D. its inability to diffuse through a cellophane membrane.
E. the acceleration of the specific reaction which it catalyzes.

269. All enzymes which have been isolated and studied to
(1.20) date,

A. alter the equilibrium point of the chemical reactions they influence.
B. contain protein. C. contain a prosthetic group.
D. remove hydrogen atoms from organic molecules.
E. act on chemical reactions which occur only outside of living cells.

270. During absorption the concentration of blood sugar in
(1.20) the hepatic portal vein is

A. greater than B. less than
C. same as the concentration of blood sugar in the hepatic vein.

271. The common bile duct is an opening for the
(1.20)

A. gall bladder. B. urinary bladder.
C. transverse part of the large intestine.
D. ascending part of the large intestine.
E. vermiform appendix.

272. Which of the following is *not* true of all protein
(1.20) molecules?

A. Each contains all of the essential amino acids.
B. Each can be converted, in large part, into carbohydrate.
C. In man, their breakdown results, eventually, mainly in the formation of urea.
D. On an "ounce-for-ounce" basis, they are less effective than common salts in exerting osmotic pressure across membranes permeable only to water.
E. By weight, they are composed of nitrogen by less than one-half.

273. In the synthesis of such foods as proteins, fats, and
(1.20) starches from sugars,

A. chlorophyll is essential.
B. enzymes are necessary.
C. nitrogenous wastes are produced.
D. cellulose is synthesized.
E. specific enzymes are not necessary.

274. During the period of milk production, the diet of the
(1.20) human mother requires supplementation mainly with

A. fats and minerals. B. fats and proteins.
C. fats and vitamins. D. minerals and proteins.
E. proteins and vitamins.

275. Acid in the duodenal portion of the small intestine
(1.20) stimulates the intestinal wall to liberate a substance which

A. stimulates the production of an acid secretion by the intestine.
B. stimulates the production of a pancreatic secretion.
C. stimulates the production of a salivary secretion.
D. increases intestinal motility.
E. increases the permeability of the intestinal cells.

276. (1.20) The amount of protein digestion brought about by pancreatic juice alone is

A. greater than B. less than
C. same as the amount of protein digestion brought about by pancreatic juice plus entrokinase.

277. (1.20) Which of the following are functions of bile?

A. Aids in the absorption of vitamin K.
B. Emulsifies fats. C. It is an excretion.
D. All of the above.

278. (1.20) The amount of fats carried from the intestine by the blood capillaries after absorption is

A. greater than B. less than
C. same as the amount of fat carried by the lacteals.

279. (1.20) Enamel lost from a tooth surface is

A. restored by action of the dentine.
B. restored by action of the living cells deep in the tooth pulp.
C. lost permanently.
D. redeposited by action of the membranes at the root of the tooth.
E. easily replaced by a competent dentist.

280. (1.20) The enzymes from the glands in the wall of the small intestine function in the

A. production of fat-splitting enzymes.
B. absorption of most of the water from the digestive tract.
C. production of starch-splitting enzymes.
D. digestion of double sugars and proteins.
E. digestion of proteins only.

281. (1.20) From the time that food is ingested until some of it is eliminated from the body of man, it must pass through various parts in the following order:

A. mouth cavity, esophagus, pharynx, stomach, large intestine, small intestine, rectum, anus.
B. mouth cavity, pharynx, esophagus, stomach, small intestine, large intestine, rectum, anus.
C. mouth cavity, pharynx, esophagus, stomach, large intestine, small intestine, rectum, anus.
D. mouth cavity, esophagus, pharynx, stomach, small intestine, large intestine, rectum, anus.
E. mouth cavity, pharynx, esophagus, stomach, large intestine, small intestine, anus, rectum.

282. (1.20) A certain adult individual is extremely bowlegged and pigeon-chested. Which of the following may have been a possible cause of this condition?

A. Deficiency of vitamin D in the diet.
B. Premature birth. C. Extreme alcoholism.
D. Lack of vitamin A in the diet.
E. Overactive thyroid gland.

283. (1.20) Which of the following procedures would be most apt to reveal the explanation of the action of the valve which permits bile to flow into the small intestine?

A. Observation of the increasing acidity of the contents of the stomach.
B. Cutting the nerves leading to the stomach.
C. Cutting the nerves leading from the stomach.
D. Cutting the nerves leading to the liver.
E. Closing off the blood vessels leading to the liver.

284. (1.20) Which one of the following symptoms would tend to indicate that the individual's diet is deficient in vitamin D?

A. His blood clots very readily.
B. His bones are deformed and his legs are bowed.
C. He is nervous and irritable.
D. He does not see well while attending the movies or when driving at night.
E. His skin is scaly and his eyes tend to be dry and crusted.

After the number on the answer sheet corresponding to the number in each blank in the following paragraph, blacken the *one* lettered space which designates the term or phrase which should fill the blank.

A. Carbohydrate. B. Protein. C. Fat.
D. All of the above.

In the process of digestion, the first food to be acted upon by an enzyme is a **285**. In the stomach, gastric protease acts upon **286**. In the small intestine bile salts emulsify **287**. Pancreatic protease attacks **288** and pancreatic amylase digests **289**. Protease in the intestinal juice acts upon **290** products, and three enzymes work upon **291** with the resultant formation of monosaccharides or simple sugars. A food containing the element nitrogen is called a **292**, while a food consisting of the elements carbon, hydrogen, and oxygen with a ratio of twice as many hydrogen atoms as oxygen atoms is called a **293**. Glycerol and fatty acids are the end products of **294** digestion, while amino acids are the end products of **295** digestion, and simple sugars are the end products of **296** digestion. All end products of digestion can pass into a villus except those of **297** digestion, it being necessary for these latter to be resynthesized prior to passage through a villus. Most of the organic food substance in protoplasm consists of **298**. A quick source of energy is obtained from the product of the digestion of **299**, as opposed to the products of digestion of **300**, which yields energy more slowly. Good nutrition requires adequate supplies of **301** in the daily diet.
(All of the above items are classified as 1.20)

302. (1.20) Absorption of digested foods by the blood occurs primarily in the

A. esophagus. B. small intestine. C. stomach.
D. large intestine. E. liver.

303. (1.20) The equation $(C_6H_{10}O_5)n + nH_2O \rightarrow nC_6H_{12}O_6$ is most closely associated with which one of the following?

A. Oxidation. B. Anabolism. C. Photosynthesis.
D. Fermentation. E. Digestion.

304. (1.20) Which one of the five substances listed below can digest foods by itself, but will function more rapidly when mixed with one of the other substances listed?

A. Saliva. B. Barley extract. C. Hydrochloric acid.
D. Pancreatic juice. E. Pepsin.

Items 305 - 311 are concerned with digestion. Select from the key the most appropriate response.

KEY

A. Mouth. B. Stomach. C. Liver.
D. Small intestine. E. Large intestine.

305. (1.20) The activities of this structure result in conservation of water in the body.

306. (1.20) Carbohydrates are broken down by the agency of bacteria in this structure.

307. Mucin is added to the food here.
(1.20)

308. Most of the digested food is absorbed here.
(1.20)

309. Urea is produced in this structure.
(1.20)

310. Glucose is converted to an insoluble carbohydrate
(1.20) which may be stored here.

311. Digestion of proteins occurs in an acid medium in this
(1.20) structure.

Items 312 - 317 are concerned with digestion. Select from the key below the most appropriate response.

KEY

A. Gall bladder. **B.** Pancreas. **C.** Salivary gland.
D. Stomach. **E.** Kidney.

312. The activities of this structure assist in regulating the
(1.20) water content in the body.

313. This structure does not secrete any products that facili-
(1.20) tate digestion.

314. This structure is involved in excretion of nitrogen
(1.20) products.

315. This structure secretes enzymes capable of digesting
(1.20) foods into glucose, amino acids, and glycerol.

316. The single enzyme secreted here acts upon starches
(1.20) only.

317. The secretion from this structure, though it facilitates
(1.20) digestion, is not an enzyme.

318. Which one of the following procedures would be most
(1.20) apt to reveal the explanation of the action of the valve which permits bile to flow into the small intestine?

A. Observation of the increasing acidity of the contents of the stomach.
B. Cutting the nerves leading to the stomach of an anesthetized animal.
C. Cutting the nerves leading from the stomach of an anesthetized animal.
D. Cutting the nerves leading to the liver of an anesthetized animal.
E. Closing off the blood vessels leading to the liver in an anesthetized animal.

319. If circulation ceased in the lymphatic system, which of
(1.20) the following would be most directly affected?

A. Fat digestion.
B. Transport between the body cells and the blood.
C. Production of red blood cells.
D. Lymphatic absorption of carbohydrates.
E. Circulation of blood platelets.

320. Indicate the best response with respect to the function-
(1.20) ing of the lymphatic system.

A. It provides a moist environment about the cells of the body.
B. It aids in disease prevention.
C. It transports fats.
D. It facilitates diffusion of various substances to and from the cells of the body.
E. More than one of the above.

321. What is the role of the thoracic duct in the transport
(1.20) of food?

A. Glucose in solution is transported through this duct.
B. It is the avenue of transport of partially digested protein.
C. Glycogen is carried through this duct to the liver for storage.
D. Toxic products of protein digestion are carried through the thoracic duct, later to be transformed into non-toxic substances.
E. The products of fat digestion are transported through the thoracic duct.

✓ **322.** A complete and accurate interpretation of the process
(1.20) whereby glucose is oxidized in the body would be

A. $C_6H_{12}O_6 + 6\ O_2 \rightarrow 6CO_2 + 6H_2O$.
B. $C_{12}H_{22}O_{11} + 12\ O_2 \rightarrow 12CO_2 + 11H_2O + \text{Energy}$.
C. $2NH_3 + CO_2 \rightarrow (H_2N)_2CO + H_2O$.
D. $C_6H_{12}O_6 + 6\ O_2 \xrightarrow{\text{Enzymes}} 6CO_2 + 6H_2O$.
E. None of these.

323. Which of the following is not characteristic of vitamins?
(1.20)

A. They exist in minute quantities in natural foods.
B. They are necessary to normal nutrition and growth.
C. Their absence from the diet produces so-called deficiency diseases.
D. They are all amines or amine-like substances.
E. Their action is probably catalytic in character.

324. Which of the following is a possible fate of glucose in
(1.20) the plant?

A. Conversion to starch.
B. Used in synthesis of amino acid.
C. Utilization by the plant in cellular respiration.
D. Two of the above. **E.** All of the above.

325. The primary function of the digestive tract (digestion)
(1.20) is to

A. make foods soluble. **B.** eliminate wastes.
C. convert foods to glucose.
D. fragment food into smaller pieces.
E. change food to energy.

326. In which of the following situations would carbohydrate
(1.20) digestion occur?

A. In a carrot root in the spring.
B. In an ameba in a 0.2% glucose solution.
C. In a liver cell after a 24-hour fast.
D. In two of the above situations.
E. In all of the situations mentioned in **A**, **B**, and **C**.

327. Four of the following are organic foods. Which one
(1.20) *is not* an organic food?

A. Proteins. **B.** Minerals. **C.** Fats.
D. Carbohydrates. **E.** Vitamins.

328. Four of the following are complex carbohydrates. Which
(1.20) one is *least* complex?

A. Starch. **B.** Glycogen. **C.** Cellulose.
D. Glucose. **E.** Granulated sugar.

329. During metabolism in man four of the following take
(1.20) place. Which one does not?

A. Proteins may be converted into carbohydrates.
B. Carbohydrates may be converted into proteins.

C. Fats may be converted into carbohydrates.
D. Carbohydrates may be converted into fats.
E. Proteins may be converted into fats.

Items 330 - 337 refer to functions of parts of the digestive tract listed in the key. Select from the key the name of the structure referred to in each item.

KEY

A. Mouth. **B.** Stomach. **C.** Pancreas.
D. Liver. **E.** Small intestine.

330. (1.20) Glands associated with this structure produce only a carbohydrate-digesting enzyme.

331. (1.20) Glands in this structure produce only protein-digesting enzymes.

332. (1.20) This structure, though it lies outside the alimentary canal, nevertheless producess carbohydrate-, protein-, and fat-digesting enzymes.

333. (1.20) Glands in this structure in the alimentary tract produce protein- and carbohydrate-digesting enzymes.

334. (1.20) The secretion from this structure does not contain any digesting enzymes.

335. (1.20) The gastric glands are found here.

336. (1.20) The juice from the glands in this structure is normally acid in nature.

337. (1.20) The cells which produce the hormone, *secretin,* are found in this structure.

338. (1.20) The equation $nC_6H_{12}O_6 \rightarrow (C_6H_{10}O_5)n + H_2O$ represents

A. transformation of a monosaccharide into a polysaccharide.
B. decomposition of dead organic matter.
C. food manufacturing.
D. hydrolysis of a monosaccharide.
E. food utilization in the body.

339. (1.20) The end product of sugar *metabolism* is

A. an amino acid. **B.** urea. **C.** glucose sugar.
D. carbon dioxide and water. **E.** glycerol.

340. (1.20) Which of the following conversions is least likely to occur in the human body?

A. Carbohydrates to proteins.
B. Carbohydrates to fats.
C. Fats to carbohydrates.
D. Proteins to carbohydrates. **E.** Proteins to fats.

341. (1.20) Acid in the duodenal portion of the small intestine stimulates the intestinal wall to liberate a substance which

A. stimulates the production of an acid secretion by the intestine.
B. stimulates the production of a pancreatic secretion.
C. stimulates the production of a salivary secretion.
D. increases intestinal motility.
E. increases the permeability of the intestinal cells.

342. (1.20) Which of the following are controlled mainly by hormones?

A. Secretion of sweat. **B.** Secretion of saliva.
C. Heart beat. **D.** Secretion of pancreatic juice.

343. (1.20) The rate of metabolism is decreased by

A. exposure to cold. **B.** physical exercise.
C. ingestion of food. **D.** rest in bed.

✓**344.** (1.20) During absorption of carbohydrates the concentration of blood sugar is highest in

A. hepatic portal vein. **B.** hepatic vein.
C. renal vein. **D.** hepatic artery.

✓**345.** (1.20) Fats are oxidized best when burned

A. with proteins. **B.** with carbohydrates.
C. alone. **D.** with urea.

346. (1.20) Most of the absorption of water occurs in the

A. liver. **B.** stomach. **C.** small intestine.
D. large intestine.

347. (1.20) Which of the following are carried away from the intestine by the lymphatic capillaries (lacteals)?

A. Amino acids. **B.** Proteins. **C.** Fats.
D. None of these.

348. (1.20) Under normal body conditions which of the following is incorrect?

A. Proteins may be changed to carbohydrates in the body.
B. Carbohydrates may be changed to fats.
C. Fats may be changed to carbohydrates.
D. Carbohydrates may be changed to proteins.

✓**349.** (1.20) Most of the energy for strenuous exercise for a short time (two minutes) is derived from

A. protein.
B. anaerobic change of glycogen to lactic acid in muscles.
C. fats. **D.** oxidation of carbohydrates.

350. (1.20) The respiratory quotient of carbohydrates may be determined by

A. measuring the amount of urea in the urine.
B. taking the blood count.
C. counting the number of inhalations per minute.
D. dividing the amount of CO_2 formed by the oxygen consumed for a given time.

351. (1.20) Which of the following parts is longest in the frog?

A. Esophagus. **B.** Stomach. **C.** Small intestine.
D. Large intestine.

352. (1.20) The transportation of dissolved foods throughout plant and animal bodies begins with

A. capillary action. **B.** osmotic pressure.
C. plasmolysis. **D.** imbibition. **E.** diffusion.

353. (1.20) Which of the following organs is *not* associated with the physical changes which food undergoes during digestion?

A. Esophagus. **B.** Hard palate. **C.** A canine tooth.
D. Duodenum. **E.** Larynx.

354. (1.20) The function of bile in the digestive process is

A. similar to that of enzymes.
B. similar to the action of soap in an oil-water mixture.
C. purely chemical and requires no catalyst or enzyme.

D. to increase the effect of gastric enzymes.
E. to make the initial changes in complex proteins.

355. (1.20) The liver is least closely associated with

A. the production of urea.
B. conversion of toxic substances into non-toxic.
C. the storage of digested food.
D. the digestion of proteins.
E. red blood cell formation.

For items 356 - 363 mark space

A. if the function or activity is associated with the *gall bladder.*
B. if the function or activity is associated with the *pancreas.*
C. if the function or activity is associated with a *salivary gland.*
D. if the function or activity is associated with the *stomach.*
E. if the function or activity is associated with the *vermiform appendix.*

356. (1.20) This structure stores a fluid which is not an enzyme but which aids in the digestion of certain foods by separating them into smaller particles and thereby increasing the total surface area exposed to digestive enzymes.

357. (1.20) This structure is sometimes removed by means of surgery with the result that the individual must restrict the amount of fat included in his or her diet.

358. (1.20) This structure is rudimentary and produces no secretion used in the digestive process.

359. (1.20) This structure produces enzymes which digest foods into glucose, amino acids, and glycerol.

360. (1.20) The single enzyme secreted here acts upon starches only.

361. (1.20) The single enzyme secreted here acts upon proteins only.

362. (1.20) Hydrochloric acid is secreted here.

363. (1.20) This structure produces a hormone which regulates carbohydrate utilization by the body.

Items 364 - 370 are concerned with the functions of certain digestive structures. Mark space

A. if the function is associated with the *mouth.*
B. if the function is associated with the *stomach.*
C. if the function is associated with the *liver.*
D. if the function is associated with the *large intestine.*
E. if the function is associated with the *small intestine.*

364. (1.20) One of the functions of this structure is water conservation.

365. (1.20) Bacteria act upon the food residues in this structure, further digesting otherwise indigestible carbohydrates.

366. (1.20) Mucin is added to the food here.

367. (1.20) Most of the digested food is absorbed here.

368. (1.20) When a sudden outburst of energy expenditure is required, this structure is stimulated to release some of its stored reserves to supply that energy.

369. (1.20) Urea is produced here in connection with protein metabolism.

370. (1.20) Bile is manufactured here.

371. (1.20) Four of the following are characteristic of enzymes. Which one is *not?*

A. They are protein substances.
B. They are products of living cells.
C. They are destroyed by heat.
D. They hasten chemical reactions.
E. They react only inside of cells.

372. (1.20) Which one of the following requires least digestive activity before it can be utilized by the body?

A. Milk. **B.** Grape sugar. **C.** Beef broth.
D. Butter. **E.** Gelatin.

373. (1.20) Which of the following can be defined only in terms of the other words in the list?

A. Reproduction. **B.** Assimilation. **C.** Metabolism.
D. Movement. **E.** Sensitiveness.

374. (1.20) What is the ultimate outcome of cellular respiration?

A. Fresh oxygen is provided for the body cells.
B. Hemoglobin is transformed into oxyhemoglobin.
C. Air is inhaled and exhaled so the body is kept constantly supplied with air.
D. Energy bound up in foods is released.
E. Carbon dioxide is removed from the cells of the body.

375. (1.20) The bacteria which usually occur in the large intestine in man

A. are detrimental to health.
B. remove most of the water from the food residues.
C. break down cellulose.
D. inhibit all further digestive activity.
E. belong to the group of organisms known as protozoa.

376. (1.20) While food is being acted upon by the peristaltic movements of the stomach wall, which of the following is added to it?

A. Ptyalin. **B.** Pancreatic juice. **C.** Bile.
D. Mucin. **E.** Hydrochloric acid

377. (1.20) Which of the following statements correctly describes the caecum in man?

A. It is a fold in the peritoneum.
B. It is the middle section of the small intestine.
C. It is a sac attached to the liver.
D. It is an outpocketing of the mesentery.
E. It is a small blind sac at the region where the small intestine joins the large intestine.

378. (1.20) Which of the following structures serves as a place of storage for absorbed sugar which is not used by the body immediately?

A. Liver. **B.** Adipose tissue. **C.** Pancreas.
D. Large intestine. **E.** Thyroid gland.

379. (1.20) Of the following foods, which would be the best source of the vitamin which helps prevent night blindness?

A. Butter and eggs.
B. Oranges and grapefruit.
C. Beef steak and pork chops.

D. Whole wheat bread and cereals.
E. None of the above.

380. (1.20) Which one of the following is a waste product when glucose is converted into energy in the body?

A. Carbon dioxide (CO_2).
B. Ammonium hydroxide (NH_4OH).
C. Hydrochloric acid (HCl).
D. An amino acid ($CH_3CH(NH_2)COOH$).
E. Nitric acid (HNO_3).

381. (1.20) It is unnecessary for man to be constantly taking food into his body because

A. digested foods are converted into glycogen and stored in such form as to be readily available to the body at all times.
B. normally, digestive processes extend from one mealtime to the next maintaining a constant source of digested nutrient for the body.
C. the blood is able to absorb enough digested nutrient after each meal to nourish the body until the next mealtime.
D. the lymph is able to absorb enough digested nutrient after each meal to nourish the body until the next mealtime.
E. stored nutrients in the form of fats are readily available at all times to nourish the body between mealtimes.

382. (1.20) Homogenizing milk renders it more easily digestible by

A. increasing the butterfat content.
B. destroying harmful bacteria.
C. clumping the butterfat into larger particles.
D. breaking up the fat globules into smaller particles.
E. predigesting the protein in the milk.

383. (1.20) A contracting muscle in man obtains energy for contraction directly from the

A. partial breakdown of glycogen.
B. complete breakdown of glycogen.
C. oxidation of lactic acid.
D. carbohydrates in the diet.
E. sugar in the blood stream.

384. (1.20) The fundamental similarity in digestion whether occurring in plants or in one-celled animals or many-celled animals is:

A. the extracellular nature of the process.
B. the synthesis of complex molecules from simpler ones.
C. the diffusion of soluble substances through membranes.
D. the intracellular nature of the process.
E. the formation of soluble compounds that can pass through plasma membranes as a result of enzyme action.

385. (1.20) The substances recombined into fat as they pass through the villus wall are:

A. amino acids. B. carbohydrates.
C. fatty acids. D. enzymes. E. proteins.

386. (1.20) Water, mineral salts, and vitamins do not have to be digested because

A. they are not foods.
B. they are non-digestible when taken in.
C. they are soluble and can pass through plasma membranes.
D. they need enzymes. E. they are insoluble.

For items 387 - 391, blacken space

A. if the item in Column I is of greater magnitude than Column II.
B. if the item in Column II is of greater magnitude than Column I.
C. if the items are of equal magnitude.

	Column I	*Column II*
387. (1.20)	Carbohydrates, fats, and proteins as foods of non-green plants.	Carbohydrates, fats, and proteins as foods of green plants.
388. (1.20)	The rate of enzyme activity at optimum temperature.	The rate of enzyme activity at a very low temperature.
389. (1.20)	The amount of enzyme at the beginning of digestion.	The amount of enzyme remaining after digestion is complete.
390. (1.20)	The effectiveness of intracellular digestion.	The effectiveness of extracellular digestion.
391. (1.20)	The likelihood of digestion going on in plants.	The likelihood of digestion going on in animals.

392. (1.20) In man the organs that secrete carbohydrate-splitting enzymes are:

A. salivary glands, pancreas, and small intestine.
B. stomach, pancreas, and small intestine.
C. salivary glands, liver, small intestine.
D. stomach, liver, and large intestine.
E. esophagus, stomach, and small intestine.

393. (1.20) During the course of a meal, hormones influence the flow of digestive juices from the following organs:

A. salivary glands, stomach, pancreas.
B. liver, gall bladder, pancreas.
C. salivary glands, stomach, large intestine.
D. salivary glands, esophagus, large intestine.
E. esophagus, stomach, liver, large intestine.

394. (1.20) The formation of secretin is stimulated by the action of

A. the alkaline material in the duodenum.
B. the bile.
C. muscle contractions in the stomach.
D. nerves to the duodenum.
E. acid food on the wall of the small intestine.

395. (1.20) When a molecule of double sugar is digested

A. it first combines with a molecule of water.
B. it splits into two simple sugar molecules with the release of water.
C. it combines with a molecule of water and then splits into two simple sugar molecules.
D. it splits into two sugar molecules.
E. it combines with another sugar molecule to form a starch.

396. (1.20) Including citrus fruits in the diet will prevent

A. night blindness. B. rickets. C. scurvy.
D. pellagra. E. beri-beri.

397. (1.20) A specific disease characterized by nervous disorder, muscular weakness, and digestive disturbance results from a lack of

A. Vitamin A. **B.** Vitamin B_1. **C.** Vitamin C.
D. Vitamin D. **E.** Vitamin E.

398. (1.20) The layer of the tooth broken down at the beginning of dental caries is the

A. peridental membrane. **B.** pulp cavity.
C. root canal. **D.** enamel. **E.** dentine.

399. (1.20) Absorption of digested foods by the blood occurs primarily in the

A. esophagus. **B.** large intestine. **C.** stomach.
D. small intestine. **E.** liver.

400. (1.20) Digestive enzymes are secreted into the digestive tract by all of the following structures associated with the digestive tract *except* the

A. gastric glands. **B.** salivary glands. **C.** liver.
D. pancreas. **E.** intestinal glands.

401. (1.20) Four of the following are characteristic of enzymes. Which one is *not?*

A. They react only inside of cells.
B. They are protein substances.
C. They are products of living cells.
D. They are destroyed by heat.
E. They hasten chemical reactions.

402. (1.20) The number of kinds of enzymes secreted by the *large intestine* is

A. greater than **B.** less than
C. the same as the number of kinds of enzymes secreted by the *liver.*

403. (1.20) The number of kinds of enzymes acting upon food in the *small intestine* is

A. greater than **B.** less than
C. the same as the number of kinds of enzymes acting upon food in the *stomach.*

404. (1.20) Which of the following is the first to break the proper sequence?

A. Pharynx (throat). **B.** Esophagus.
C. Stomach. **D.** Colon. **E.** Duodenum.

405. (1.20) Carbohydrates are used in the body in the form of

A. a double sugar. **B.** starch. **C.** glycogen.
D. glucose. **E.** sucrose.

406. (1.20) Glucose in the human body may come from the digestion and absorption of carbohydrate food or from

A. the breakdown of vitamins.
B. the union of carbon dioxide and water in the body.
C. the conversion of amino acids.
D. the decomposition of waste products.
E. the conversion of ptyalin.

407. (1.20) Which of the following secretes enzymes capable of chemically digesting all three classes of food?

A. Large intestine. **B.** Stomach. **C.** Esophagus.
D. Pancreas. **E.** Gall bladder.

408. (1.20) Which of the following structures in man's body normally serves as a common passageway for both food and air?

A. Pharynx. **B.** Glottis. **C.** Esophagus.
D. Trachea. **E.** Larynx.

409. (1.20) What is the role of hydrochloric acid in the stomach?

A. Its presence in the stomach is a symptom of digestive disorder resulting in indigestion.
B. It serves only to cause stomach ulcers.
C. It is a digestive enzyme which hydrolyzes fats.
D. It aids in the digestion of raw starches.
E. It increases the effectiveness of pepsin in the digestion of proteins.

410. (1.20) When pancreatic juice acts upon butter the resulting products are likely to be

A. carbon dioxide and water. **B.** glucose and starch.
C. glycerol and fatty acids. **D.** all of the above.
E. none of the above.

411. (1.20) During metabolism in man which of the following conversions does not take place?

A. Proteins to carbohydrates.
B. Carbohydrates to proteins.
C. Fats to carbohydrates.
D. Carbohydrates to fats.
E. Proteins to fats.

Items 412 - 416 involve functions of, or deficiencies associated with, the lack of certain vitamins. For each item select the most appropriate response, then mark the corresponding answer space.

KEY

A. Vitamin A. **B.** Vitamin B. **C.** Vitamin C.
D. Vitamin K. **E.** None of these.

412. (1.20) Since this vitamin is essential for normal blood clotting, it may be administered before surgery to patients whose blood is unduly slow in clotting.

413. (1.20) The so-called sunshine vitamin is abundant in the liver oils of various fish. Its absence in the diet results in the bone disease known as rickets.

414. (1.20) The diet of a person suffering from night blindness may be deficient in this vitamin.

415. (1.20) If a certain vitamin is lacking in the diet of white rats they become sterile.

416. (1.20) The vitamin which is abundant in oranges, lemons, and grapefruit is essential to the production of sound teeth.

417. (1.20) In the following pair, blacken space **A** if the first element of the pair is definitely greater than the second; space **B** if the second is definitely greater than the first; and space **C** if the two are approximately equal.

A. Number of enzymes in saliva.
B. Number of enzymes in pancreatic juice.

418. (1.20) The basic inorganic raw materials utilized by green plants in the formation of the complex compounds needed in their own metabolism are

A. glucose and oxygen.
B. oxygen, fats, and carbon dioxide.
C. carbohydrates, proteins, and fats.
D. carbon dioxide, water, and mineral salts.
E. amino acids, carbohydrates, and carbon dioxide.

419. (1.20) In the following pair, blacken space **A** if the first element of the pair is definitely greater than the second; space **B** if the second is definitely greater than the first; and space **C** if the two are approximately equal.

A. Number of enzymes produced by the large intestine.
B. Number of enzymes produced by the small intestine.

420. (1.20) In man, the most effective mechanism for regulating the internal body heat loss or conserving and maintaining it at a constant level while the external environment ranges from sub-zero to torrid temperatures is (are) the

A. protein foods in the diet. **B.** body hair.
C. sweat glands. **D.** lungs. **E.** kidneys.

421. (1.20) When lean beef is digested the resulting product(s) is/are

A. glycerol. **B.** urea. **C.** polysaccharides.
D. glucose. **E.** amino acids.

422. (1.20) In recent years a method of tracing the fate of individual chemical elements involved in body metabolic processes has been made possible by the use of

A. radio-active isotopes. **B.** antibiotics.
C. synthetic hormones. **D.** chemical micro-analysis.
E. the electron microscope.

423. (1.20) All the foods capable of being digested by the enzyme secretion of the pancreas would include

A. carbohydrates only. **B.** fats and carbohydrates.
C. fats, proteins, and starches.
D. sugars, starches, and proteins.
E. fats and proteins.

424. (1.20) A substance which is *not* a carbohydrate is

A. starch. **B.** sugar. **C.** cellulose.
D. glycogen. **E.** amino acid.

425. (1.20) Consider the following terms: cell, nucleus, digestion, respiration, protoplasm, and growth. Which of the following is the most inclusive concept that embodies the terms presented?

A. Cell structure. **B.** Metabolism.
C. Mitotic cell division. **D.** Reduction-division.
E. Excretion.

426. (1.20) The structure which plays no active part in chemical digestion is the

A. villus. **B.** liver. **C.** pancreas.
D. mouth. **E.** esophagus.

427. (1.20) If an individual had no pytalin in his saliva,

A. foods containing starch would not digest in his body.
B. digestion of starches would be taken care of by the enzymes in his stomach.
C. digestion of starches would take place wholly in his small intestine.
D. he could not possibly live very long without taking intravenous injections.
E. he could not possibly survive under any circumstances.

428. (1.20) The food which would be almost wholly undigested after having passed through both the mouth and the stomach would be

A. potato. **B.** lean beef. **C.** apple.
D. butter. **E.** jello.

429. (1.20) The pancreatic duct of a dog is tied so that nothing can pass through it. As a consequence

A. the dog will probably die within two weeks.
B. carbohydrate metabolism will be seriously deranged.
C. fats will pass through the dog's body wholly undigested.
D. a severe state of tetany (muscle twitching) will develop in two or three days.
E. the dog's body will continue to function normally in every respect.

430. (1.20) The Vitamin D precursor in the body will not be activated by

A. outdoor light reflected from a northern sky.
B. direct outdoor sunlight.
C. light reflected from the water of a lake.
D. direct sunlight entering a glassed-in solarium or sun porch.

431. (1.20) Surgical removal of a person's gall bladder would

A. cause very premature death.
B. seriously derange the body's execretory function.
C. cause the liver to atrophy.
D. require some restriction in diet.
E. not interfere with normal living and eating.

After the exercise number on the answer sheet blacken the one lettered space which designates the most similar structure, condition, or process.

432. (2.10) The function of branches of the gastro-vascular cavity of a flatworm:

A. The lungs of a higher vertebrate.
B. The nematocysts of the hydra.
C. The nephridia of an earthworm.
D. The circulatory system of a more complex animal.
E. The pancreas of a higher animal.

433. (2.10) Which one of the following is the best description of what is meant by basal metabolic rate (B.M.R.)?

A. The daily calorie output of a person exercising lightly and subsisting on the minimum diet to remain alive.
B. The oxidation rate in an active individual going about his daily routine and maintaining normal weight.
C. The respiratory coefficient in base industry organisms (algae and protozoa).
D. The oxidation rate which will just maintain the life processes of a person in a state of rest.
E. The amount of heat required to raise the temperature of one kilogram of water one degree centigrade.

For items 434 - 449, after each item number on the answer sheet, blacken the *one* lettered space which designates the correct answer. Refer to diagram on Page 106.

434. (2.20) The site where most of the digestion and absorption of food takes place:

A. 5. **B.** 6. **C.** 8. **D.** 9. **E.** 10.

435. (2.20) Receives food and passes it directly to the esophagus:

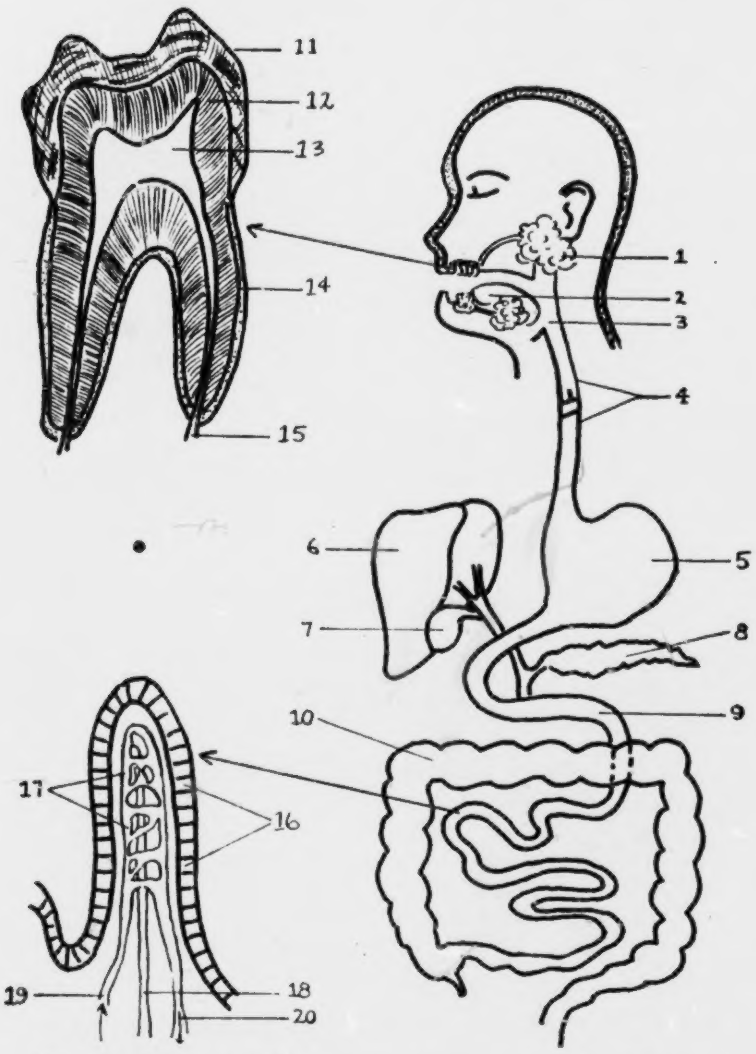
A. 1. **B.** 2. **C.** 3. **D.** 4. **E.** 5.

436. (2.20) It receives food in relatively large quantities about three times a day, holds it while it undergoes mechanical and chemical changes, then passes it on in small portions at frequent intervals:

A. 3. **B.** 4. **C.** 5. **D.** 6. **E.** 8.

437. (2.20) It secretes a digestive fluid and it also forms an internal secretion which aids in oxidation of glucose:

A. 1. **B.** 5. **C.** 6. **D.** 7. **E.** 8.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438. (2.20) It absorbs largely water and functions in the elimination of waste:

A. 4. **B.** 5. **C.** 7. **D.** 9. **E.** 10.

439. (2.20) It forms a secretion containing a starch-splitting enzyme called salivary amylase:

A. 1. **B.** 6. **C.** 7. **D.** 8. **E.** 9.

440. (2.20) It serves as a reservoir for bile in intervals between digestion and upon stimulation pours bile into the duodenum:

A. 5. **B.** 6. **C.** 7. **D.** 8. **E.** 9.

441. (2.20) It functions in the production of bile and forms an internal secretion which regulates the changing of glucose to glycogen and the reverse of this reaction:

A. 1. **B.** 5. **C.** 6. **D.** 7. **E.** 8.

442. (2.20) Decay here makes the tooth sensitive to heat, cold, and sweet substances:

A. 11. **B.** 12. **C.** 13. **D.** 14. **E.** 15.

443. (2.20) Decay here kills living tissue and if extensive is called an abscess:

A. 11. **B.** 12. **C.** 13. **D.** 14. **E.** 15.

444. (2.20) A passageway for nerves and blood vessels:

A. 11. **B.** 12. **C.** 13. **D.** 14. **E.** 15.

445. (2.20) A channel which carries away most of the product absorbed as glycerin and fatty acids:

A. 15. **B.** 17. **C.** 18. **D.** 19. **E.** 20.

446. (2.20) The place where protein digestion is begun:

A. 4. **B.** 5. **C.** 8. **D.** 9. **E.** 10.

447. (2.20) Most of the water and mineral salts are absorbed here:

A. 5. **B.** 7. **C.** 8. **D.** 9. **E.** 10.

448. (2.20) Villi increase the absorptive area of this region:

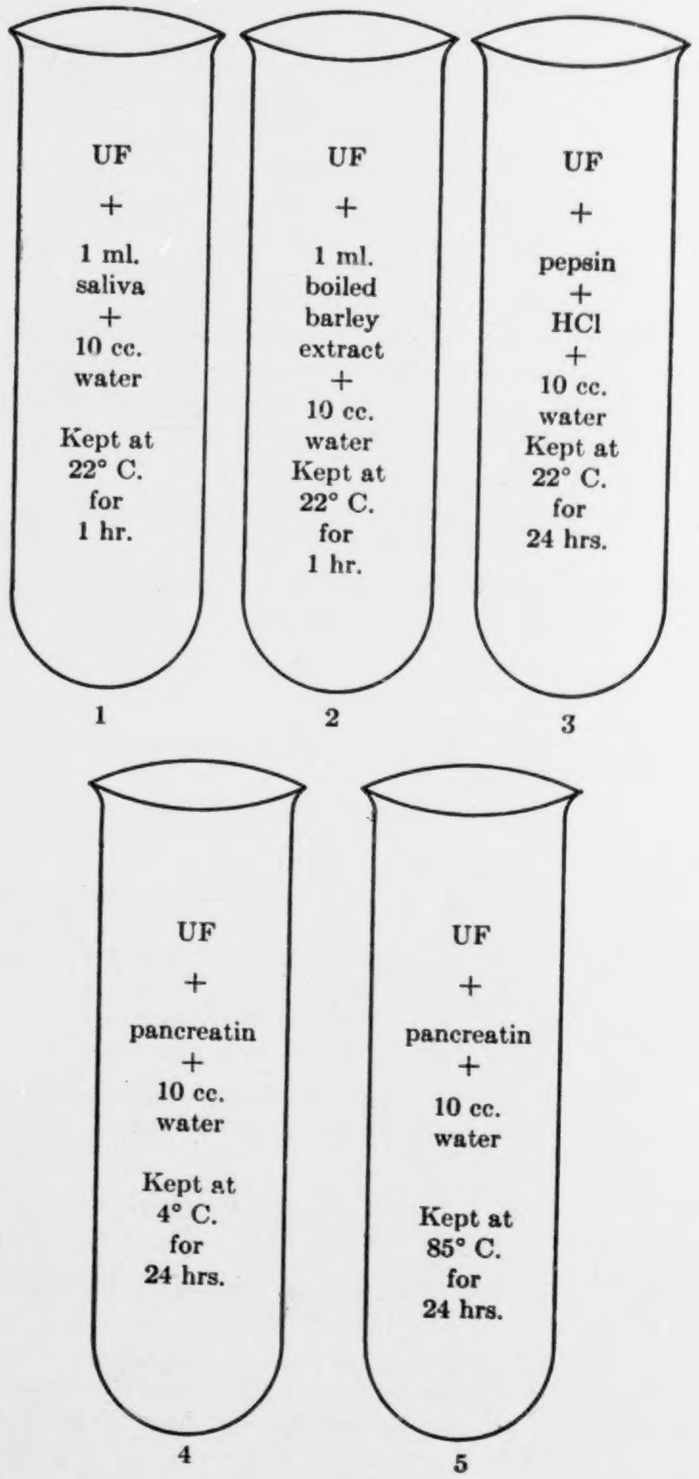
A. 2. **B.** 3. **C.** 4. **D.** 9. **E.** 10.

449. (2.20) It secretes an enzyme that splits fats into a diffusible form:

A. 1. **B.** 6. **C.** 8. **D.** 9. **E.** 10.

Items 450 - 455 are concerned with digestion.

A cubic centimeter of an unknown insoluble food (UF) was placed in each of five test tubes which were then subjected to the conditions indicated below.


UF + 1 ml. saliva + 10 cc. water Kept at 22° C. for 1 hr.
1
UF + 1 ml. boiled barley extract + 10 cc. water Kept at 22° C. for 1 hr.
2
UF + pepsin + HCl + 10 cc. water Kept at 22° C. for 24 hrs.
3
UF + pancreatin + 10 cc. water Kept at 4° C. for 24 hrs.
4
UF + pancreatin + 10 cc. water Kept at 85° C. for 24 hrs.
5

For items 450 - 454 use the numbers of the test tubes as the key. Each item is in some way related to one and only one test tube of material after the period of time specified in each case has elapsed.

450. (2.20) The contents of this test tube when mixed with Benedict's solution and heated produced a yellow-orange color.

451. (2.20) On the basis of the results described in the previous item, one of the test tubes contains no enzyme—either active or inactivated—capable of digesting this particular food sample.

452. (2.20) The enzyme in one of the test tubes could never become functional.

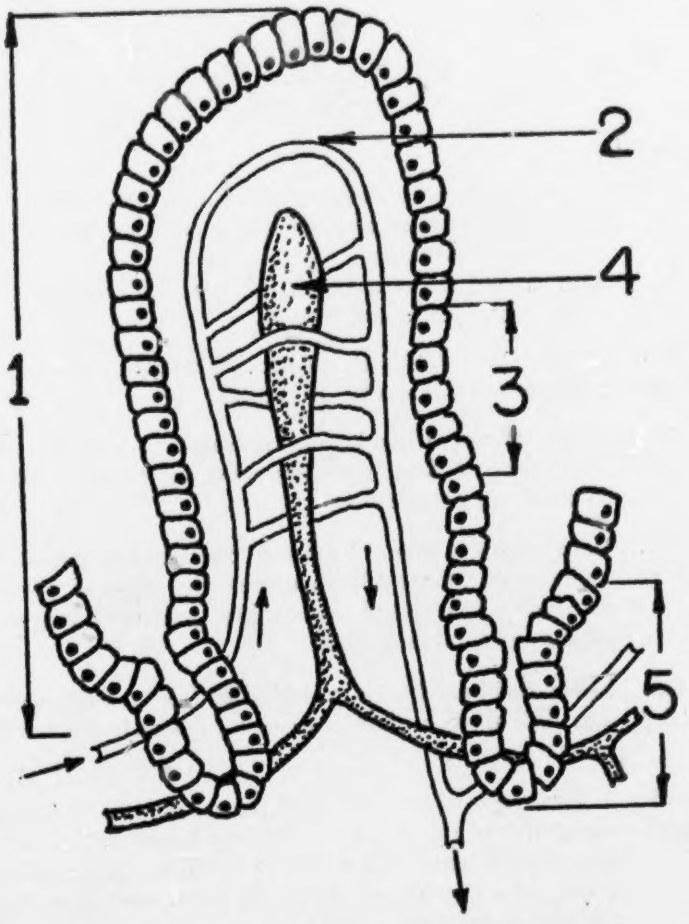
453. (2.20) Drinking ice water at meal-time is unhygienic.

454. (2.20) Drinking extremely hot chocolate or coffee at meal-time impairs enzyme action in the digestion of other food eaten at the same meal.

455. (2.20) The unknown food sample in the above experiment was

A. protein. B. fat. C. glucose. D. starch.
E. inorganic salt.

For items 456 - 464, after each item number on the answer sheet, blacken the lettered space which designates the correct answer.



NAMES OF STRUCTURES

456. (2.20) Structure *1*:

A. Gastric gland. B. Villus.
C. Intestinal gland. D. Appendix.

457. (2.20) Structure *2*:

A. Lacteal. B. Lymph tube. C. Capillary.
D. Artery.

458. (2.20) Structure *3*:

A. Muscle. B. Peritoneum. C. Epithelium.
D. Pericardium.

459. (2.20) Structure *4*:

A. Lacteal. B. Lymph gland. C. Artery.
D. Vein.

460. (2.20) Structure *5*:

A. Gastric gland. B. Intestinal gland.
C. Villus. D. Mucus gland.

FUNCTIONS OF STRUCTURES

461. (2.20) Structure *1*:

A. Increases the absorptive surface of the intestine.
B. Secretes a juice necessary for digestion.
C. Has no known function in man.
D. Produces a hormone regulating the rate of heart beat.

462. (2.20) Structure *2*:

A. Carries away absorbed sugars and amino acids.
B. Removes fats. C. Secretes a digestive juice.
D. Resynthesizes fatty acids and glycerine into fats.

463. (2.20) Structure *4*:

A. Carries away all types of digested food.
B. Acts as a filter for removing harmful substances from the lymph.
C. Carries away simple sugars and amino acids.
D. Carries away most of the absorbed fats.

464. (2.20) Structure *5*:

A. Absorbs digested food. B. Produces gastric juice.
C. Produces secretin. D. Secretes intestinal juice.

For items 465 and 466 refer to the key below:

KEY

- **A.** A glucose solution is treated with alkaline-copper solution.
- **B.** A series of test tubes was prepared with various combinations of egg white, pepsin, hydrochloric acid, boiled pepsin, and/or saliva. After standing variable periods of time the contents of each tube were treated with nitric acid.
- **C.** A piece of closed cellulose tubing is filled with glucose solution and then immersed in pure water.
- **D.** A glucose solution contained in a test tube is boiled with saliva and then treated with alkaline-copper solution. Thirty minutes later the test is repeated.

465. (2.20) Physical examinations invariably include a urinalysis to reveal, among other things, proper utilization of certain foods.

466. (2.20) The digestion of one type of nutrient begins in the stomach and continues through the small intestine.

467. (2.20) The direction of movement of glucose in lymph is determined by

A. gravity. B. relative temperatures.
C. relative concentrations.
D. proximity to nerve cells. E. size of blood vessels.

For items 468 - 472 use the following data as the key and consider each key category except E as a complete experiment in itself.

KEY

	Enzyme & Substrate	*Hours*	*Reaction*	*Temp.*	*End Products*
A.	Pepsin, HCl, Lean Beef, H_2O	12	Acid	37°C.	Pepsin, HCl, Amino Acids
B.	Pepsin, HCl, Lean Beef, H_2O	12	Alkaline	37°C.	Pepsin, HCl, Lean Beef
C.	Pepsin, HCl, Lean Beef, H_2O	12	Alkaline	100°C.	Pepsin, HCl, Lean Beef
D.	Pepsin, HCl, Lean Beef, H_2O	12	Acid	100°C.	Pepsin, HCl, Lean Beef
E.	None of the above.				

468. (2.20) In which experiment was the temperature many degrees lower than body temperature?

469. (2.20) In which experiment did protein digestion occur?

470. (2.20) In which experiment did carbohydrate digestion occur?

471. (2.20) With respect to temperature, which experiment served as the control for experiment B?

472. (2.20) With respect to reaction, which experiment served as the control for experiment B?

Items 473 - 475 are based upon the following:

Substance X, mixed with water, will cause iodine to turn blue-black.
Substance X, when mixed with Substance Y, and incubated at 40°C. for 10 minutes, will no longer cause any color change in iodine solution.

473. (2.20) On the basis of the foregoing data, you hypothesize that, of the following, Substance X probably is

A. protein. B. fat. C. sugar. D. starch.
E. amino acid.

474. (2.20) You also hypothesize that, of the following, Substance Y probably is

A. hydrochloric acid. B. saliva. C. insulin.
D. pepsin. E. glycerol.

475. (2.20) If Substance Y had been boiled before being used in the above experiment there would again be the color change in iodine to blue-black. This indicates that Substance Y contains a (an)

A. hormone. B. carbohydrate. C. enzyme.
D. indicator. E. testing solution.

For items 476 - 478 use the key listed below:

KEY

A. A glucose solution is treated with alkaline-copper solution.
B. A series of test tubes was prepared with various combinations of egg white, pepsin, hydrochloric acid, boiled pepsin, and/or saliva. After standing variable periods of time the contents of each tube were treated with nitric acid.
C. A series of test tubes was prepared with water, 10% hydrochloric acid, saliva, boiled saliva, and/or barley extract. After standing in a water bath for 40 minutes the contents of each tube were treated with iodine and alkaline-copper solution.
D. A piece of closed cellulose tubing is filled with glucose solution and then immersed in pure water.
E. A glucose solution contained in a test tube is boiled with saliva and then treated with alkaline-copper solution. Thirty minutes later the test is repeated.

476. (2.20) The digestion of one type of nutrient is begun in the mouth, postponed in the stomach, and completed in the small intestine.

477. (2.20) Physical examinations invariably include a urinalysis to reveal, among other things, proper utilization of certain foods.

478. (2.20) The digestion of one type of nutrient begins in the stomach and continues through the small intestine.

An experiment was conducted to test the hypothesis. The enzyme in saliva loses its ability to act when the saliva is mixed with the enzymes from gastric juice. Items 479 - 483 present statements regarding this experiment. Consider each statement as containing all the information available and evaluate it according to the key.

KEY

A. Provides information that is valid and can be accepted as sufficient to alone prove the *accuracy* of the hypothesis.
B. Provides information that is valid and can be accepted as sufficient to prove the inaccuracy of the hypothesis.
C. Due to the lack of proper controls or other faulty experimental technique, the information cannot be considered in determining the accuracy or inaccuracy of the hypothesis.
D. Provides no information of any kind to prove or disprove the hypothesis.

479. (2.20) Ptyalin was mixed with pepsin. This mixture converted a starch solution to a sugar solution.

480. (2.20) A subject was incited to produce saliva by seeing a very sour lemon. A sample of this saliva converted a starch solution to a sugar solution.

481. (2.20) Juice dripping from a tube swallowed into the stomach was treated chemically to extract the enzymes. These enzymes when mixed with saliva converted a starch solution to a sugar solution.

482. (2.20) Saliva was mixed with gastric juice from a calf's stomach. This mixture failed to convert a starch solution to a sugar solution.

483. (2.20) A few drops of vinegar were placed on the tongue to incite flow of saliva. This saliva was mixed with gastric juice and poured into a starch solution. The solution was kept warm for one hour. No sugar was present at the end of the hour.

484. (2.20) A nutritionist would consider the slogan "An apple a day keeps the doctor away" in connection with the step in the scientific method termed

A. analysis of the problem.
B. testing or retesting an hypothesis.

C. extending facts to principles.
D. acting on a conclusion.
E. None of the above.

485. (2.20) In general the value of a slogan in solving problems scientifically depends upon

A. its interpretation of what the public is thinking about a problem.
B. provision of a ready-made pattern for behavior.
C. its use as evidence in testing a hypothesis.
D. saving time by removing the need for experimentation.
E. None of the above; it has no value.

486. (2.20) A person was given a meal of glucose, salt, protein, and water. How many foods required digestion?

A. One. **B.** Two. **C.** Three. **D.** Four.
E. None.

487. (2.20) "The appearance of the stomach found to be digested after death show that digestion neither depends on a mechanical power, nor contractions of the stomach, nor on heat, but on something secreted in the coats of the stomach, and thrown into the cavity, which animalizes the food or assimilates it to the nature of blood."
—John Hunter, *On the Digestion of the Stomach After Death*, 1772.

Part of that something is now known to be

A. pepsin. **B.** trypsin. **C.** ptyalin.
D. sucrase. **E.** lipase.

488. (2.20) "We have learned that sugar exists in large quantity in the liver; that this sugar dissolves or pours itself out into the blood which passes through the liver, and thus is carried by the suprahepatic veins and the inferior vena cava into the right heart, where it is constantly found."
—Claude Bernard, *The Origin of Sugar in the Animal Body*, 1848.

A. The idea that a carbohydrate exists in the liver has since been proved false.
B. The systemic system pours into the left, not the right, side of the heart.
C. The vena cava is an artery, not a vein.
D. The sugar is not poured into the blood directly, but first passes down the bile duct from the liver to the intestine where it is absorbed.
E. Glycogen is the carbohydrate found in the liver.

For items 489 - 492 select from the key the statement which best applies for each item, then mark the answer space corresponding to its number in the key.

The total function of the digestive system of animals appears to involve

KEY

A. the glandular secretions mixed with the food.
B. the area of absorptive surface with which the food comes in contact.
C. correlation between structure of the organ and type of food eaten.
D. protection of the digestive organs from infections.
E. maintenance of adequate cellular respiration within the organ involved.

489. (2.20) Man has a greater variety of types of teeth than does the cat.

490. (2.20) There is one more chamber in the heart of mammals than in amphibians.

491. (2.20) The digestive system of the frog undergoes marked changes during the growth of the frog.

492. (2.20) The lining of the small intestine in humans contains a great number of villi.

493. (2.20) "How can the intestine lying some distance away cause the pancreas to release its digestive enzymes at just the right moment?" The foregoing quotation would be considered a

A. demonstrable fact. **B.** tentative hypothesis.
C. problem. **D.** principle. **E.** conclusion.

494. (2.20) Digestion, as it occurs in the amoeba, provides evidence that

A. enzymes are unessential for the process.
B. amoeba can use only simple food materials.
C. the amoeba can use only the food materials that have been partially digested by another animal.
D. protoplasm can secrete enzymes.
E. some animals derive energy from sources other than the digestion of food.

495. (2.20) Why does the consumption of large quantities of fats by the Eskimos tend to keep them warm?

A. Fat molecules are less oxidized than the molecules of any other class of foods.
B. Fats are soluble in alcohol.
C. The fat molecule is simpler than the protein molecule.
D. Some food molecules contain phosphorus and sulphur.
E. Fats are more readily obtainable than any other kind of food.

Enzymes	*Products Formed*	*Absorption*
A. salivary amylase	**A.** simple sugars	**A.** lacteals
B. protease	**B.** double sugars	**B.** portal vein
C. lipase	**C.** amino acids	**C.** villus capillaries
D. maltase	**D.** fatty acids and glycerine	**D.** jugular vein
E. lactase		**E.** intestinal arteries

Fats are acted on in the human intestine by the enzyme **496** which changes them to **497**; these substances upon absorption enter the **498** and are carried by the lymphatic system until they enter the blood stream. Starch is first acted on by **499** which changes it to **500**. This action is completed in the small intestine by inverting enzymes and the product formed is **501** which upon absorption enters the **502**. Proteins are changed in the stomach by **503** which breaks the large molecules down to intermediate products. This proteolytic action is continued in the intestine by other **504** enzymes, the final products being **505** which upon absorption enter **506**.

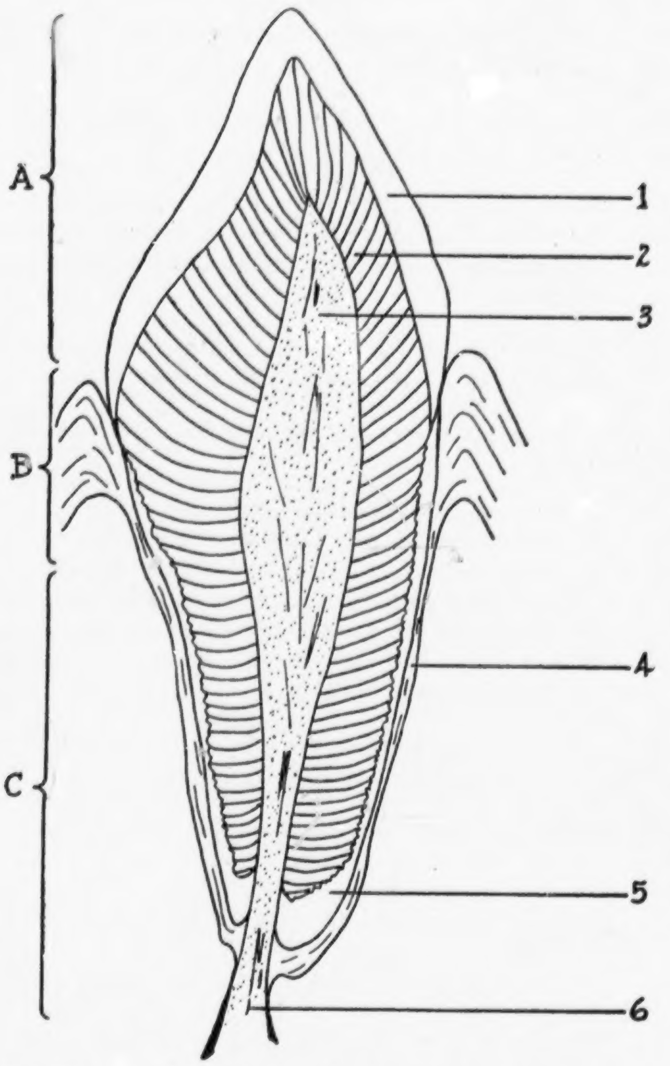
Items 507 - 510 are based on the diagram on Page 110.

507. (2.20) The part labeled B in the diagram is the

A. pulp cavity. **B.** neck. **C.** crown.
D. gum. **E.** root.

508. (2.20) The part labeled 5 in the diagram is the

A. dentine. **B.** enamel. **C.** cementum.
D. peridontal membrane. **E.** root canal.



509. The part labeled 1 in the diagram is the
(2.20)

A. enamel. **B.** dentine. **C.** peridontal membrane.
D. root canal. **E.** cementum.

510. The part labeled 3 in the diagram is the
(2.20)

A. cementum. **B.** dentine. **C.** pulp cavity.
D. peridontal membrane. **E.** enamel.

511. A tooth sensitive to heat, cold, and sweet substances
(2.20) indicates:

A. inflammation of the gums.
B. decay in the root canal. **C.** pyorrhea.
D. excessive formation of tartar.
E. decay in the enamel.

512. Of what advantage is it to the higher animals that the
(2.20) inside wall of the intestine is folded and undulating rather than a uniformly flat surface?

A. The absorption rate is increased.
B. There are more secretory glands.
C. More villi make contact with the food.
D. Two of the above. **E.** All of the above.

513. What function is normally served by the enzyme which
(2.20) is present in barley extract?

A. It digests the stored food in the barley plant.
B. It makes barley taste better when eaten by animals.
C. It digests barley in the animal body when the barley is eaten by animals.
D. It aids in the manufacture of glucose in photosynthesis.
E. It has no known function.

514. If some diluted pancreatic juice is poured over ground
(2.20) peanuts and corn starch in a beaker and this is allowed to stand until the following day four of the following products are likely to be present in the beaker. Which one *is not?*

A. Glucose. **B.** Glycerol. **C.** Amino acids.
D. Hydrochloric acid. **E.** Fatty acids.

515. In "Obstructive Jaundice," the bile duct is plugged with
(2.20) gall stones and consequently bile cannot reach the small intestine. As a result, the digestion of which one of the following classes of foods would be interfered with?

A. Proteins. **B.** Fats. **C.** Carbohydrates.
D. Vitamins. **E.** Inorganic foods.

Items 516 - 521 involve certain chemical processes fundamental to an understanding of biological science. For each item select from the key the appropriate response, then mark the corresponding answer space.

KEY

A. $6CO_2 + 6H_2O + \text{energy} \rightarrow C_6H_{12}O_6 + 6O_2$
B. $C_6H_{12}O_6 + C_6H_2O_6 \rightarrow C_{12}H_{22}O_{11} + H_2O$
C. $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + \text{energy}$
D. $(C_6H_{10}O_5)_n + nH_2O \rightarrow nC_6H_{12}O_6$
E. None of the above.

516. This equation represents cellular respiration.
(2.20)

517. This equation represents photosynthesis.
(2.20)

518. This equation represents protein synthesis.
(2.20)

519. This equation represents digestion.
(2.20)

520. This equation represents the transformation of carbo-
(2.20) hydrate into fat.

521. This equation represents the transformation of simple sugar to double sugar.

For items 522 - 525 select the best response from the following key.

KEY

A. The statement is a hypothesis.
B. The statement is a conclusion drawn from inferences made as a result of sensory impressions (observations).
C. The statement is a biological principle.
D. The statement is false.

522. Saliva contains a carbohydrate digesting enzyme.
(2.20)

523. Protoplasm is largely a coordinated system of hundreds
(2.20) of thousands of enzymes.

524. Metabolic processes are carried out in the presence of
(2.20) organic catalysts which are manufactured by the organism and are present in every living cell.

525. Since digestive enzymes are produced by living things,
(2.20) they are active only within the organism.

For items 526 - 529 select the best response from the following key.

KEY

- **A.** Both the statement and the reason are true.
- **B.** The statement is true and the reason is false.
- **C.** The statement is true and the reason is unrelated to the statement.
- **D.** Both the statement and the reason are false.
- **E.** The statement is false and the reason is unrelated to the statement.

526. (2.20) Enzymes are necessary for the digestion of complex foods *because* all foods must be broken down before they can be absorbed by the living organism.

527. (2.20) A drop of iodine added to a glucose solution turns the glucose solution blue *because* color indicators are used to test for the presence of certain organic substances.

528. (2.20) Enzymes are present in saliva *because* the body needs such enzymes in order to digest starch.

529. (2.20) Fats are first broken down into simpler substances in the stomach *because* it is here that the digestive juice from the pancreas first comes into contact with the fats.

530. (2.20) Which of the following responses most adequately explains the biblical expression "All flesh is grass"?

- **A.** Plant life could not exist on the earth if there were no animal life.
- **B.** When animals die their carcasses disintegrate and furnish mineral nutrients to plants.
- **C.** $C_6H_{12}O_6 + 6O_2 \rightarrow \text{Energy} + 6CO_2 + 6H_2O$.
- **D.** Vitamins are essential to the normal growth of living organisms.
- **E.** $\text{Carbohydrates} + \boxed{\begin{array}{l}\text{Nitrogen}\\ \text{Phosphorus}\\ \text{Sulphur}\end{array}} \rightarrow$ Amino acids $\rightarrow$ Proteins.

The following is a description of a nutritional experiment. Read it and answer the exercises which follow it (items 531 - 539).

... It has been known that if birds are restricted to polished rice as food they soon develop a multiple neuritis highly suggestive of the human nutritional disease, beriberi, a disease of the nervous system that afflicts people who subsist largely on a diet of polished rice. Birds fed whole rice did not manifest these symptoms. Accordingly, ... whole rice was provided to the inmates of prisons and asylums where beriberi was a scourge, in place of the polished rice that had been the staple article of diet. The results were clear-cut and impressive. Beriberi was eradicated from all those institutions where substitution of whole rice was made. ... The substance preventative and curative for this disease was later isolated from rice polishings (the outer hulls) in crystalline form ... it is now known as thiamine (vitamin B_1), and is manufactured synthetically in large quantities. This is practically the only present source of thiamine. It has become a familiar chemical and is one of the best known vitamins.

"Fifty Years of Progress in Nutritional Research," E. V. McCollum, *Scientific Monthly*, Vol. 71, No. 6, Dec. 1950, by permission.

After each item number on the answer sheet, blacken space

- **A.** if the statement is true on the basis of evidence given above.
- **B.** if the statement is true, but not on the basis of evidence given above.
- **C.** if the statement is false on the basis of evidence given above.
- **D.** if the statement is false, but not on the basis of evidence given above.

531. (3.00) The cause of pellagra is unknown.

532. (3.00) Beriberi is a disease of the nervous system.

533. (3.00) Thiamine is a vitamin which prevents beriberi.

534. (3.00) Commercial thiamine (vitamin B_1) is now produced from rice polishings in large quantities.

535. (3.00) Thiamine is found in polished rice.

536. (3.00) Many whole grain cereals are good sources of thiamine.

537. (3.00) Lack of thiamine causes beriberi in humans.

538. (3.00) The cure for most vitamin deficiency diseases is unknown.

539. (3.00) Substitution of whole rice for polished rice as the staple article of diet can cause beriberi to disappear.

A study of teen-age diets in Maine showed that both girls and boys were apt to run low in Vitamin C and calcium. Girls also were very low in iron. A study of diets of Chicago families showed that high school children had less milk and fewer servings of fruit, vegetables, meat, poultry, and eggs than those in elementary schools. High school sophomores in a New York State study had less protein and less milk, fruits, and vegetables containing Vitamin C than needed for their age. Studies in Tennessee, New York, and Maryland revealed that older children were less likely to get their quotas of calcium and Vitamins A and C than those under nine years of age.

On the basis of this article and your knowledge of nutrition, for items 540 - 558, blacken space

- **A.** if the statement is true and supported by the facts given.
- **B.** if the statement is true though not supported by facts in the articles.
- **C.** if the statement, although related to facts in the article, is still an hypothesis.
- **D.** if the statement is false.

540. (3.00) Vitamin C deficiency can be overcome by eating tomatoes or oranges or drinking their juices.

541. (3.00) Teenagers can be trusted to choose foods wisely.

542. (3.00) Deficiency in calcium may be the result of drinking "cokes" in place of milk and fruit juices.

543. (3.00) A typical teen-age diet of "hot dog" sandwiches, pop, potato chips, and pie may result in vitamin and mineral salt deficiency.

544. (3.00) There is evidence that high school students eat less meat than elementary school pupils.

545. (3.00) Girls eat less sensibly than boys.

546. (3.00) The study of foods and nutrition is unnecessary in high school and junior college.

547. (3.00) Custom and home training is sufficient to assure good food habits.

548. (3.00) Malnutrition is common in the United States.

549. (3.00) Reducing diets that omit butter and cream may lead to Vitamin A deficiency.

550. (3.00) Diets low in iron may lead to anemia.

551. (3.00) Only city boys and girls eat unwisely.

552. (3.00) Calcium deficiency leads to poor bone and tooth development.

553. (3.00) High school students should be urged to eat more milk, fruits, and vegetables.

554. (3.00) Adequate proteins can be obtained by generous inclusion of fruits and leafy vegetables in the diet.

555. (3.00) The tendency of girls to go on reducing diets may lead to nutritional deficiencies.

556. (3.00) Including tomatoes, either fresh or canned, in the diet will prevent Vitamin C deficiency.

557. (3.00) Although ice cream is popular with teenagers, apparently they do not eat enough to supply themselves with sufficient Vitamin A.

558. (3.00) Health education in high schools has not improved food habits of students.

559. (3.00) A measure of the rate of metabolism of any mammalian organ except the lungs is

- **A.** the difference in urea content of blood in the arteries and veins associated with the organ.
- **B.** the difference in glucose content of blood in the arteries and veins associated with the organ.
- **C.** the difference in lactic acid content of blood in the arteries and veins associated with the organ.
- **D.** All of the above. **E.** None of the above.

✓ **560.** (3.00) The pancreatic ducts of an experimental animal are tied off.

- **A.** There is a sudden increase in blood pressure and heart rate.
- **B.** The animal exhibits a voracious appetite, drinks excessively, and urinates frequently.
- **C.** The carbohydrate metabolism is deranged.
- **D.** Digestion of proteins and carbohydrates is slowed and fats are not digested.
- **E.** Digestion of fats is slowed, but there is no effect on protein or carbohydrate digestion.

✓ **561.** (3.00) A man suffers a deficiency of secretion of bile salts from his liver. How does this affect his digestion?

- **A.** His digestion is impaired only with respect to the digestion of fats. Carbohydrates and proteins are digested without trouble.
- **B.** His digestion is impaired only with respect to the digestion of proteins.
- **C.** His fat digestion is seriously impaired and carbohydrate and protein digestion affected, since pancreatic enzymes act best in an alkaline medium.
- **D.** Fat digestion is prevented, since the bile carries the enzyme functioning in fat digestion which is produced in the liver.
- **E.** The only effect is the slower digestion of fats, since emulsification of fats is reduced.

Items 562 - 566 are based upon the following experiment.

Problem: What factor or factors cause rats to be susceptible to a certain virus-induced condition?

Hypothesis: Diet is the factor which is responsible for susceptibility to the condition induced by virus V.

Experimental procedure:
Six pens were prepared, each to house 20 laboratory rats chosen at random from a stock of 120 rats.

A special food (SF) was prepared containing adequate amounts of carbohydrates, fats, proteins, vitamins, and minerals.

The rats in the six pens were subjected to the following feeding formulas:

Pen A—These 10 rats were fed the special food (SF).
Pen B—These 20 rats were fed the special food (SF) with carbohydrates omitted.
Pen C—These 20 rats were fed the special food (SF) with both *fats and carbohydrates omitted.*
Pen D—These 20 rats were given food containing *vitamins and minerals only.*
Pen E—These 20 rats were given food containing *minerals only.*
Pen F—These 20 rats were given *no food at all.*

Mark the items according to this key:

KEY

- **A.** A logical observation or efficient step in procedure.
- **B.** Indicates that additional variable factors were being or had been introduced into the study.
- **C.** An observation that would not have been likely.
- **D.** Unrelated to the success or failure of the experiment.

562. (3.00) The rats used to introduce virus V into the rats in pens A, B, C, D, and E were trapped at the city dump and placed in the pens as soon as these rats from the dump showed symptoms of virus V.

563. (3.00) The rats in pens E and F appeared to lose weight most rapidly but failed to show symptoms of virus V.

564. (3.00) All of the rats in pen F outlived all of the rats in all of the other pens.

565. (3.00) Adequate water and suitable temperature were provided all of the rats in the six pens throughout the experiment.

566. (3.00) Each new batch of food prepared for the rats in pen D was tested with nitric acid solution.

Items 567 - 574 refer to the following experiment. Ten healthy white rats, one month old, and all of the same litter, were used in the first part of the experiment. On February 13, they were separated into two groups of five each (two males and three females), each rat being placed in a separate cage. They were fed according to the following schedule:

Feb. 13 - Feb. 19—Both groups received 30 gm. per rat of bread and milk and kernels of whole corn.

Feb. 20 - May 20—
Group A: 30 gm. of bread and milk, five kernels of whole corn, and 50 mg. of dried defatted powder from the *posterior* lobe of the ox pituitary gland per rat.
Group B: 30 gm. of bread and milk, five kernels of whole corn, and 50 mg. of dried defatted powder from ox ovary or testicle alternately per rat.

During the feeding the rats of Group A ate 7932 gm. of food and the controls, Group B, ate 7774 gm.

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The increase in average weight in per cent of original average weight was as follows:

Time	*Group A*	*Group B*
Feb. 13 - Feb. 20	33%	35%
Feb. 13 - Apr. 1	179%	180%
Feb. 13 - May 20	290%	293%

For the second part of the experiment, ten additional young healthy white rats one month old were used. On October 23, the litter was placed in two groups of five each (two males and three females) with each rat in a separate cage. These rats were labelled Groups C and D and were fed according to the following schedule:

Oct. 23 - Oct. 29—Both groups received 30 gm. of bread and milk and five kernels of whole corn per rat.
Oct. 30 - Jan. 31—
Group C: 30 gm. of bread and milk, five kernels of whole corn, 50 mg. of powdered, dried, defatted *anterior* lobe of the ox pituitary gland per rat.
Group D: 30 gm. of bread and milk, five kernels of whole corn, 50 mg. of dried, defatted, powdered ox ovary or testicle alternately per rat.

During the feeding the rats of Group C ate 7472 gm. of food and Group D ate 7771 gm.
The increase in average weight in per cent of average original weight was as follows:

Time	*Group C*	*Group D*
Oct. 23 - Oct. 30	37%	41%
Oct. 23 - Dec. 10	220%	252%
Oct. 23 - Jan. 31	370%	463%

567. (3.00) The most complete statement of the main problem studied in the experiment described is:

- **A.** How does the anterior portion of the pituitary gland affect growth?
- **B.** How does the posterior portion of the pituitary gland affect growth?
- **C.** Is the pituitary gland an endocrine or a ductless gland?
- **D.** How do extracts of certain endocrine glands differ in their effects on the growth rates of male and female rats?
- **E.** How does the anterior portion of the pituitary gland differ from the posterior portion in its effect on growth?

For items 568 - 574 evaluate the steps in plan and procedure according to the following key:

KEY

- **A.** Of no significance in the solution of the main problem.
- **B.** Adequately considered or controlled.
- **C.** Inadequately considered or not controlled.

568. (3.00) The question of whether these glandular preparations are destroyed through the digestive process.

569. (3.00) The fact that rats stop growing when they reach maturity.

570. (3.00) The differences in growth rates of the two sexes in rats.

571. (3.00) The fact that rats are rodents and oxen are ungulates.

572. (3.00) The question of whether the rats would have grown normally on the regular diet.

573. (3.00) The possibility that the rats were of different pedigree strains with different inherited growth rates.

574. (3.00) The possibility that some of the rats would be more aggressive and crowd the weaker rats away from the food container.

For items 575 - 577 key lists are presented in which brief reference is made to some biological information. Following these key lists are several descriptions of situations involving biological information. Choose from the key list the information that would be *most* helpful in providing a biological explanation of the situation described in the statement. The items from the key list may have to be used more than once or in some cases not used at all.

KEY

- **A.** The vermiform appendix may become irritated and inflamed by bacterial action or abnormal fecal material.
- **B.** In man there is a partial canal from the abdominal region to the scrotum.
- **C.** Calcareous materials may crystallize and lodge in the tubes leading from the kidneys.
- **D.** It is possible for the duct leading from the gall bladder to become obstructed.
- **E.** The glands of internal secretion as well as those provided with ducts can be excited by subconscious behavior.

575. (3.00) An individual experiences a feeling of fullness after eating a fatty meal. This persists to a state of discomfort and after a few days the whites of the eyes tend to take on a yellow color.

576. (3.00) The color of fecal materials is of interest to physicians treating certain abnormal conditions of the alimentary tract.

577. (3.00) An individual experiences abdominal pains centering in the region of the navel. The pain persists for four or five days and may be accompanied by cramps and nausea. The patient shows a high white cell count.

Each of the items 578 - 584 presents a brief description of an experiment followed by a conclusion drawn from the experiment. Use the *most* applicable statement of the key to evaluate the conclusion. Observations made during the course are to be considered factual in marking these items.

KEY

- **A.** The conclusion does not answer the problem prompting the experiment.
- **B.** The conclusion is not in agreement with the facts of the experiment.
- **C.** There are not enough facts revealed by the experiment to make the conclusion valid even though the conclusion is in agreement with biological science.
- **D.** Due to the lack of proper controls or other poor experimental technique, the observations from the experiment prompted a conclusion in disagreement with accepted biological science.
- **E.** The conclusion is tentatively justified.

578. (3.00) In attempting to prove that a red-leaved plant can manufacture its own food, a red leaf when boiled in alcohol imparted a green color to the alcohol and another red leaf when crushed and viewed under the microscope revealed small green bodies.
Conclusion—Red-leaved plants can carry on photosynthesis.

579. (3.00) To learn what forces prompt the rise of water in plant stems, a stalk of celery was stood in a red dye solution. The ends of the strings were stained red.
Conclusion—Water rises in a plant stem through the fibrovascular bundles.

580. (3.00) To determine the effect of a salt solution on corn seedlings, a specimen was placed in a salt solution and it was observed to wilt badly.
Conclusion—A plant will suffer the loss of water when placed in a salt solution.

581. (3.00) To prove that growing plants give off moisture, a healthy plant and a dead plant were placed under identical inverted glass jars. The following day moisture was observed to collect on the inside of both jars.
Conclusion—Living and dead plants give off water vapor.

582. (3.00) To determine the food value of a one ounce slice of bread it was completely burned and the amount of heat given off very carefully measured by allowing it to be absorbed in 25 liters of water. The temperature of the water was raised 3°C.
Conclusion—A one ounce slice of this bread completely oxidized in the body would yield 75 large calories of energy.

583. (3.00) To prove that pancreatic juice contains enzymes that digest fats, a student placed plain pancreatic juice in a beaker with some corn oil and some boiled pancreatic juice in a beaker with some butterfat. He later observed some glycerol collecting in the first beaker.
Conclusion—Pancreatic juice contains enzymes capable of digesting starch.

584. (3.00) To show that the amount of hemoglobin in the blood varies with individuals, samples of blood were taken from three people, placed in small glass tubes and then the tubes were broken at regular intervals. Observations showed that the stringiness of the blood at the breaking point varied with the individuals.
Conclusion—The tendency of blood to become fibrous when exposed to the air varies with individuals.

585. (3.00) A moving company operating vans out of a large mid-western city encouraged those truck drivers making distant trips to include carrots in their diet as frequently as possible. The chief basis for this course of action might be that

- **A.** vitamin A is essential to the formation of visual purple in the rods of the retina.
- **B.** these particular drivers were subject to long periods of exposure to cold.
- **C.** a deficiency of vitamin D in the diet may result in the bone disease known as rickets.
- **D.** the work entailed is very strenuous requiring a well-balanced diet.
- **E.** a lack of vitamin C in the diet might result in scurvy which for centuries has plagued sailors on long expeditions.

586. (3.00) One hundred uniform sized disks are cut from the leaves of a sunflower plant at dawn. These disks are designated A. Another 100 disks are cut from the leaves of the same plant at sunset of the same day after the plant has stood in bright sunlight all day. These disks are designated B. A third set of 100 disks are cut from the leaves of the same plant at dawn of the following day after the plant has stood in darkness during the night. These disks are designated C. All disks are dried in an oven at 105°C. until they lose no further weight by continuing drying. Which one of the following is the most accurate statement on the basis of the above data?

- **A.** The B disks have the largest dry weight.
- **B.** The C disks have the largest dry weight.
- **C.** The C disks have the smallest dry weight.
- **D.** The A disks have the largest dry weight.
- **E.** The B disks have the smallest dry weight.

587. (3.00) because

- **A.** growth takes place at night as well as in the daytime.
- **B.** starch is hydrolyzed and withdrawn to the roots for storage as fast as it is made.
- **C.** all the starch burns up at 105°C.
- **D.** sugar is changed to starch and stored in the leaves during the night.
- **E.** during the period of sunlight starch accumulates faster than it can be withdrawn and stored.

588. (3.00) Pains caused by stomach ulcers can be partially alleviated by an operation in which the branches of the vagus nerves regulating the flow of gastric juice are severed. Another result likely to accompany this operation would be

- **A.** delayed digestion of proteins
- **B.** impaired digestion of fats.
- **C.** improper digestion of carbohydrates.
- **D.** reduced chemical digestion of all classes of foods.

Items 589 - 592 refer to the following situation.

Four test tubes contain certain food substances as follows:

- **A.** Test tube 1 contains a food substance which turns yellow on the addition of nitric acid.
- **B.** Test tube 2 contains a food substance which turns blue-black on the addition of iodine.
- **C.** Test tube 3 contains a food substance which when heated with Benedict's solution turns an orange-red.
- **D.** Test tube 4 contains a food substance which when rubbed on brown paper and allowed to dry spots the paper with a translucent spot.

589. (3.00) The food substance in test tube 1 has a chemical formula of

A. $C_6H_{12}O_6$. **B.** $(C_6H_{10}O_5)n$. **C.** $C_{51}H_{98}O_6$.
D. $C_{18}H_{36}O_2$. **E.** $C_{3032}H_{4816}O_{872}N_{780}S_8Fe_4$.

590. (3.00) The substance in test tube 2 is used principally by the body to

- **A.** release energy. **B.** build protoplasm.
- **C.** serve in a catalytic capacity.
- **D.** prevent a deficiency disease.
- **E.** none of the above.

591. (3.00) The contents of test tube 3 is a substance which is also the major constituent of

A. maple syrup. **B.** potatoes. **C.** peanut oil.
D. egg white. **E.** white rice.

592. (3.00) The food substance in test tube 4 is otherwise known as

A. ascorbic acid. **B.** tocopherol.
C. nicotinic acid. **D.** calciferol.
E. none of the above.

593. (3.00) An unknown food was tested with the following results: a) Iodine—no change in color; b) Nitric acid—no color change; c) Sudan III—no color change; d) Benedict's solution—color became brick red upon heating. Which one of the following foods would most likely have produced the above results?

A. Lean beef. B. Irish potato. C. Lemon juice.
D. Butter.
E. None of the above would do it; the food must have been something not listed.

Items 594 and 595 are based upon the following paragraph and Figure 8 below.

"With few exceptions enzymes are very specific in their action. Only a limited number of substances can be acted upon by any given enzyme, and in many cases only one.

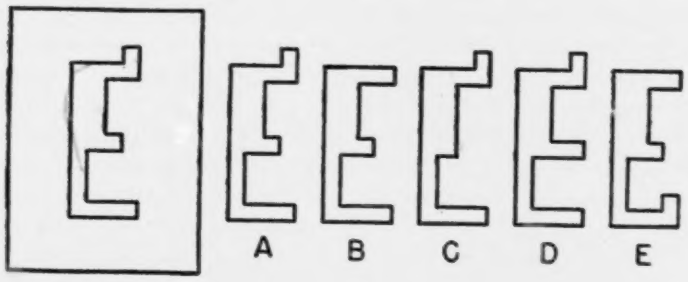


Fig. 8.–Illustrating the lock and key hypothesis of enzyme specificity. A key the shape of A, B, or C would fit the lock and might unlock it, while a key the shape of D or E could not be made to enter the lock.

"Thus invertase acts only upon cane sugar and lactase upon milk sugar; but maltase is able to hydrolyze both maltose and alpha methyl glucoside; and emulsin, one of the glucosidases, can decompose milk sugar, amygdalin, arbutin, salicin, coniferin, and still other substances. It is probable, however, that emulsin is really a mixture of enzymes.

"This specific action may be explained on the basis of the lock and key hypothesis, which was first proposed by Pasteur to explain why an enzyme would attack a dextro sugar and not a levo one. If we assume that the compound contains some special grouping or configuration of molecules which the enzyme may 'fit,' then only enzymes with the corresponding configuration will be able to 'unlock' the compound and decompose it."

Quoted from PRINCIPLES OF PLANT PHYSIOLOGY
by Oran Raber (Revised Edition) published by
The Macmillan Company, New York, 1937.

594. (3.00) If keyhole B in Figure 8 above represents a food to be digested which key pattern would correspond to the specific enzyme that could enter and digest the food? (Mark space 1, 2, 3, 4, or 5, to designate the key pattern selected.)

595. (3.00) If keyhole B in Figure 8 represents cooked starch the key pattern that fits would represent

A. pepsin. B. steapsin. C. rennin.
D. ptyalin. E. trypsin.

Read the following paragraph before answering items 596 - 606.

The action of a certain nationally distributed laxative is described in the advertisements as being "nice and gentle". An impartial research organization upon analyzing this nationally advertised laxative found that the active drug in it is phenolphthalein, a chemical substance which is notorious for its capacity to cause skin eruptions, blisters and other toxic reactions in sensitive persons. The hazard is further increased by the fact that the laxative is sold in the form of tasty chocolate tablets which leads parents to regard it as innocent and tempts children to try the whole box instead of a single tablet. Several deaths are recorded which are known to have resulted from the ingestion of excessive amounts of phenolphthalein-containing laxatives.

For items 596 - 606 mark

space 1 if the statement is probably true according to the principles of biology.
space 2 if the statement is probably false according to the principles of biology.
space 3 if there is no basis for judging the truth or falsity of the statement.

596. (3.00) Normal peristalsis in the digestive tract is maintained largely by the roughage in the natural diet and the mere bulk within the tract.

597. (3.00) Too much roughage in the diet may be injurious to the mucosa of the colon.

598. (3.00) Consistency of the stools is a better criterion of adequate evacuation than is frequency of movements.

599. (3.00) Most of the troubles and failures of man can be attributed to constipation.

600. (3.00) Self-diagnosis and self-medication with a widely advertised cathartic is usually the best procedure for alleviating constipation.

601. (3.00) Most radio and magazine advertisements of patent medicines, vitamin capsules, and other products for self-medication present implications which lead to conclusions that are both illogical and unfounded.

602. (3.00) Judging from the volume of sales of nostrums the majority of the people in the U. S. prefer to be duped rather than make an effort to find out the true value of a product.

603. (3.00) The effectiveness of some cathartics, such as epsom salts, is based upon the principle of increasing the normal water absorption by the colon.

604. (3.00) Habitual and excessive use of any cathartic tends to aggravate the condition it is intended to alleviate.

605. (3.00) There is no real place in medicine for cathartics.

606. (3.00) Patent-medicine manufacturers have long and effectively exploited human ills.

Items 607 - 613 are based on the data in the table below.

After a period of starvation, which depleted the glycogen from the liver, an animal was fed a meal of pure protein. Analysis of certain constituents of the blood in the hepatic portal vein and hepatic vein was made and recorded in the table below.

Table 1. Analysis of Blood in Vessels
Four Hours After Protein Meal

	Concentrations of		
	Amino Acids	Urea	Glucose
Hepatic portal vein (to liver)	8.0 mg. per 100 cc.	30.0 mg. per 100 cc.	80.0 mg. per 100 cc.
Hepatic vein (from liver)	6.0 mg. per 100 cc.	30.7 mg. per 100 cc.	81.0 mg. per 100 cc.

For items 607 - 611 mark space

A. if the statement is warranted by the evidence.
B. if the statement is contradicted by the evidence.

C. if the statement cannot be judged on the basis of the evidence.

607. (3.00) The liver removes amino acids from the circulatory system.

608. (3.00) Amino acids are synthesized in the liver from urea.

609. (3.00) Urea is either manufactured or stored in the liver.

610. (3.00) The liver either manufactures or holds in storage a reserve supply of sugar.

611. (3.00) Adrenalin was responsible for the increase in glucose content of the blood from 80 mg. per 100 cc. to 81 mg. per 100 cc.

"Eight milligrams of alanine (an amino acid) containing carbon atoms which were C^{14} and nitrogen atoms which were N^{15} were injected into the hepatic portal vein of an animal. An analysis of the urea taken from a sample of blood from the hepatic vein showed that some of the nitrogen of the urea was N^{15}. An analysis of glucose taken from the hepatic vein showed that some of the glucose molecules contained C^{14} atoms."

On the basis of the above information answer item 612 using the same key as for items 607 - 611.

612. (3.00) Amino acids are catabolized in the liver into urea and glucose.

613. (3.00) "In a diabetic animal there is excretion of glucose in the urine even though the animal is fed a carbohydrate-free diet." This statement tends to support which one of the following hypotheses?

A. The liver discharges amino acids into the circulatory system.
B. Urea is either manufactured or stored in the liver.
C. Amino acids are synthesized in the liver from urea.
D. Amino acids are catabolized in the liver into urea and glucose.
E. None of the above.

Items 614 - 618 are based upon the following excerpt from *The Green Earth,* by Harold W. Rickett. By permission from the Ronald Press Company. Copyright 1943.

"Recently an experiment was performed involving two test tubes containing a solution of various foods and other substances into which a fungus had been introduced. In one tube an abundant growth covered the surface of the food; in the other—nothing. The fungus in both was the same, the time and temperature and light to which the two cultures had been subjected were the same, the food was the same—except that in the first a vitamin had been placed, in the second it was lacking. This particular vitamin may be purchased in pure form at a cost of $10.00 for 0.075 milligram, seventy-five ten-thousands of a milligram or about two-and-one-half millionths of a millionth of an ounce. The price amounts to something over $62,000,000 a pound. And, at this rate, the quantity of the vitamin necessary to differentiate beween the two test tubes, to permit abundant growth in the one, was about *one cent's worth!*

"The effects of some vitamins are detectable when even smaller quantities than this are present. Inexpressibly minute as the trillionth of an ounce seems to us, it is still a fairly large amount for a chemist. Atoms and molecules are much smaller. The pennyworth of vitamin mentioned above contained many *millions* of molecules. As human beings we suffer from the deficiencies of our sense organs. We are so large, so course, that we cannot perceive even cells without the aid of a microscope, far less molecules and atoms; and we have trouble in imagining the teeming and active world of units which are invisible to us. At the other extreme we are so small that we have equal trouble in extending our mental tentacles enough to grasp the stars and the facts of stellar space.

". . . it is pertinent here to notice that one of the most striking and peculiar characteristics of living matter is one that has been scarcely considered as a candidate for divine honors. This is its relation to substances in extremely minute quantities. Every natural process to whose core we manage to penetrate is likely to reveal itself as conditioned by some enzyme, some vitamin, some hormone, or some system of such substances. They are in no sense mysterious—as the popular press loves to label them. They are definite chemical substances, many obtainable (at a cost) in pure form. Even their mode of action is yielding to careful physiological research, and what we do not know today will be disclosed by the science of tomorrow. Certainly this fact, that so much of the life of protoplasm is absolutely dependent upon fantastically small quantities of certain organic substances, is one of its most distinctive properties. The bean that sprouts from the cracked soil of your garden is digesting its insoluble foods by means of enzymes which its protoplasm makes, it is righting itself in the world by means of auxins, which its apical meristems make, its roots and its stem are elongating by virtue of vitamins which the green parts make. These substances, these and others like them, are what ensures that the bean plant shall behave like a bean plant, shall be a coordinated mechanism, an organism, rather than a mere sprawling amorphous lump of expanding matter."

614. (4.20) The major point which this reading passage establishes is that

A. obtaining adequate vitamins in the diet is a very expensive undertaking.
B. the range of sensitivity of man's sense organs is extremely limited.
C. an infinitesimally small amount of a growth-regulating substance is capable of producing an enormous effect.
D. a bean plant is an organism rather than a formless mass of organic material.
E. enzymes, hormones, and vitamins are very complex substances.

615. (4.20) In the experiment described in the reading passage the second test tube would be regarded as

A. the standard of comparison.
B. the experimental tube.
C. the reserve tube—to be used if something went wrong with the first one.
D. the salvage tube—to be used in retrieving the valuable material after the experiment was finished.
E. none of the above.

616. (4.20) Which one of the following statements concerning the initial hypothesis in this experiment is most applicable?

A. There was no initial hypothesis.
B. The original hypothesis, though not stated here, can be deduced from the results.
C. The hypothesis occurs in the statement of outcome of the experiment.
D. The initial hypothesis states that what we do not know today will be disclosed by the science of tomorrow.
E. It is not important that there be an initial hypothesis—most scientists formulate their hypotheses after the experiments have been performed.

617. (4.20) Fungi are characterized by which one of the following?

A. They are usually green in color due to the presence of chlorophyll in their cells.
B. They belong to the same phylum as the amoeba.
C. All fungi are unicellular.
D. Fungi reproduce slowly.
E. Fungi are saprophytic organisms.

618. (4.20) Which one of the following statements concerning man's senses is correct?

A. Man has the most highly developed senses of all living organisms on the earth.
B. Keenness of natural sense perception parallels intellectual development.
C. Man is the only organism on the earth whose senses may be defective.
D. Plants as well as animals have sense organs.
E. Man is probably the only organism on the earth capable of extending the power of his sense perception by auxiliary means.

14. *Energy Transformation*

ENERGY TRANSFORMATION

1. The class of foods having the highest caloric value per
(1.10) unit weight is

A. protein. B. fat. C. carbohydrate.
D. vitamin. E. mineral salt.

2. Four of the following are always associated with the
(1.20) release of energy in the body. Which one is not directly involved in energy release?

A. Oxygen. B. A source of organic material.
C. Nitrogen. D. Carbon dioxide. E. Water.

3. The chemical reactions that are entered into by the
(1.20) elements and compounds which make up living protoplasm always involve

A. catabolic activity. B. anabolic activity.
C. energy transformation. D. food manufacture.
E. food utilization.

4. The oxidation of substances within cells causes
(1.20)

A. the production of heat.
B. the storage of energy within the cells.
C. the formation of food.
D. the lowering of the temperature of the cells.
E. the destruction of waste products.

5. What property of fats gives them a higher fuel value
(1.20) per unit of weight than any other food?

A. The fat molecule is the most complex of all organic molecules.
B. When fats are formed from fatty acids and glycerol several molecules of water are eliminated in the reaction.
C. Fats are insoluble in water.
D. The fat molecule containing a relatively small amount of oxygen can accept much more.
E. Fats can be hydrolyzed.

6. Which one of the following includes the other four?
(1.20)

A. Heat. B. Light. C. Energy. D. Motion.
E. Electricity.

7. Which of the following is a possible fate of glucose in
(1.20) the plant?

A. Inversion to starch.
B. Inversion to amino acid.
C. Used by the plant in cellular respiration.
D. Two of the above. E. All of the above.

8. Which of the following items does not belong with
(1.20) the other four?

A. Element. B. Compound. C. Matter.
D. Energy. E. Atom.

9. "These substances unite easily with atmospheric oxygen,
(1.20) and are consumed in the process, thus producing the heat required for the vital machinery."

To which of the following might the author of the above quotation have been referring?

A. Mineral foods. B. Vitamins. D. Proteins.
D. Carbohydrates. E. All of these.

10. The glycogen of the muscle is used directly in
(1.20)

A. the repair of worn-out parts of the cell.
B. energy production.
C. the formation of enzymes.
D. two of the above. E. all of the above.

For items 11 - 19, after the answer sheet number corresponding to that of each of the following paired items, blacken space

A. if the item at the left is greater than the item at the right.
B. if the item at the right is greater than the item at the left.
C. if the two items are of the same magnitude.

Note: The magnitude of one of the two things compared may be zero.

11. (1.20)	The importance of respiration to plants.	....	The importance of respiration to animals.
12. (1.20)	The diffusion of oxygen through the walls of the bronchi.	....	The diffusion of oxygen through the walls of the alveoli.
13. (1.20)	The number of impulses passing along the phrenic and intercostal nerves during inspiration.	....	The number of impulses passing along the phrenic and intercostal nerves during expiration.
14. (1.20)	The number of impulses passing to the respiratory center along the vagus nerve at the beginning of inspiration.	....	The number of impulses passing to the respiratory center along the vagus nerve at the end of inspiration.
15. (1.20)	The contraction of the intercostal muscles during normal inspiration.	....	The contraction of the intercostal muscles during normal expiration.
16. (1.20)	The length of the chest cavity when the diaphragm contracts.	....	The length of the chest cavity when the diaphragm relaxes.
17. (1.20)	Amount of energy required in the synthesis of one gram of $C_6H_{12}O_6$.	....	Amount of energy released when one gram of $C_6H_{12}O_6$ is oxidized.
18. (1.20)	The concentration of O_2 in the blood in the capillaries of muscle tissues.	....	The concentration of O_2 in the muscle tissues.
19. (1.20)	The importance of diffusion in the respiration of one-celled animals and plants.	....	The importance of diffusion in the respiration of many-celled animals and plants.

20. Of all the energy necessary to carry on the body proc-
(1.20) esses in man, by far the greatest amount is released by

A. epithelial tissue. B. muscular tissue.
C. nervous tissue. D. connective tissue.

21. In the breakdown of glycogen occurring in skeletal
(1.20) muscle the energy released is directly utilized in the

A. contraction of the muscle fibres.
B. reaction restoring organic phosphates.
C. relaxation of the muscle fibres.
D. reaction producing CO_2 and H_2O.

22. Compounds which diminish in quantity as the activity
(1.20) of the muscle increases are

A. carbon dioxide, lactic acid, fatty acids.
B. organic phosphates, oxygen, glycogen.

C. oxygen, inorganic phosphates, carbon dioxide.
D. water, oxygen, lactic acid.

23. (1.20) The "all or none" principle can be applied to

A. skeletal muscle, heart, and nerve fibres.
B. heart muscle only. **C.** nervous tissue only.
D. all of the tissues of the body.

24. (1.20) Muscle fatigue is primarily due to

A. reduction of the lactic acid.
B. an over-supply of glycogen.
C. a complete contraction of all of the muscle fibres.
D. an accumulation of lactic acid.

25. (1.20) Muscle enlargement which is developed by work or training involves an

A. increase in the number of muscle fibres.
B. increase in the size of each muscle fibre.
C. accumulation of lactic acid which distends the muscle fibre.
D. accumulation of glycogen which distends the muscle fibres.

26. (1.20) Experiments have shown that an isolated muscle fibre will continue to contract in response to a stimulus for some time in an atmosphere of nitrogen. Despite the lack of oxygen in this environment, this is possible because of the

A. supply of stored oxygen in the muscle fibres.
B. release of oxygen from the water in the cells.
C. energy liberated from glycogen and organic phosphates.
D. energy liberated from glycogen alone.

27. (1.20) During one muscle twitch more time is spent in the (**A.** latent period; **B.** period of actual work; **C.** period of contraction; **D.** relaxation period) than in any other period.

28. (1.20) The efficiency of a muscle is greater

A. immediately after the period of treppe, or warm-up.
B. two hours after the period of treppe.
C. before treppe. **D.** during the period of treppe.

29. (1.20) Rapid breathing commences during muscular activity and continues for a period after such work. The latter period may be described as paying the (**A.** glycogen; **B.** muscle fibre; **C.** oxygen; **D.** CO_2) debt.

30. (1.20) Excess lactic acid accumulates in the muscle cells.

A. Fatigue occurs. **B.** Muscular activity is promoted.
C. The individual suffers from rheumatism.
D. The period of treppe takes place.
E. The breakdown of organic phosphates begins.

31. (1.20) The most important outcome, to the living organism, of cellular respiration is

A. energy release. **B.** oxygen intake.
C. carbon dioxide discharge. **D.** food intake.
E. none of these.

32. (1.20) If equal weight samples of each of the following foods are prepared, the greatest amount of food energy could be obtained from the sample of

A. simple sugar. **B.** double sugar.
C. vitamin C. **D.** fat. **E.** protein.

33. (1.20) Whether we actually burn our foods in a flame, or whether we eat and digest them, the total amount of energy that can be obtained from the same amount of food is the same in both instances. One difference between the two processes is in the

A. physical process involved.
B. disintegration of the nuclear structure of the molecules.
C. amount of effective radiation produced.
D. exothermic energy produced.
E. rate of the reaction.

For items 34 - 50, after each exercise number on the answer sheet, blacken space

A. if the item in Column I is of greater magnitude than that in Column II.
B. if the item in Column I is of less magnitude than that in Column II.
C. if the two items are of essentially the same magnitude.
D. if the two items are not comparable.

	Column I		*Column II*
34. (1.20)	Regulation of temperature by heat production in man.	....	Regulation of temperature by heat loss in man.
35. (1.20)	The degree of contraction of a muscle.	....	The speed of transmission of nerve impulses to the muscle.
36. (1.20)	The amount of heat produced in the body in a week's time.	....	The amount of heat lost in the regulation of the body temperature in the same time.
37. (1.20)	The amount of heat produced by a man at hard physical work in a temperature of 80°F. in a given length of time.	....	The amount of heat produced by the same man walking slowly along the street in a temperature of 35°F. in the same length of time.
38. (1.20)	The total surface area of the skin of a person.	....	The total surface area of the lining of the alveoli of lungs of the same person
39. (1.20)	The concentration of urea in the capsule.	....	The concentration of urea in the urinary tubule.
40. (1.20)	The reabsorption of glucose into the blood from the capsular fluid.	....	The reabsorption of urea into the blood from the capsular fluid.
41. (1.20)	The amount of urea and uric acid normally excreted by the skin.	....	The amount of urea and uric acid excreted by the skin in cases of kidney disease.
42. (1.20)	The importance of the sweat glands in secreting waste products of metabolism.	....	The importance of the sweat glands in regulating the body temperature.

	Column I	Column II
43. (1.20)	The loss of heat by an individual through evaporation of sweat in a given unit of time in a hot, dry climate.	.... The loss of heat by the *same* individual through evaporation of sweat in the same amount of time in a hot, humid climate.
44. (1.20)	The amount of heat lost in a man by the warming of exhaled air to body temperature.	.... The amount of moisture lost by saturating inhaled air.
45. (1.20)	The degree of difference in constituents of blood plasma and glomerular fluid.	.... The degree of difference in constituents of blood plasma and urine.
46. (1.20)	Desirability of obtaining energy for muscular contraction from carbohydrates and fats.	.... Desirability of obtaining energy for muscular activity from proteins.
47. (1.20)	The efficiency of a muscle fiber during the warming up period.	.... The efficiency of a muscle fiber during the interval immediately following the warming up period.
48. (1.20)	The change in the urine as it passes through the ureter.	.... The change in the urine as it passes through the urethra.
49. (1.20)	The extent to which muscle enlargement developed by work or training is due to an increase in the number of muscle fibers.	.... The extent to which muscle enlargement developed by work or training is due to an increase in the size of each fiber.
50. (1.20)	The amount of time spent during the relaxation period of a single muscle twitch.	.... The amount of time spent during the period of actual work of a single muscle twitch.

51. (1.20) Four of the following are always associated with the release of energy in the body. Which one is not directly involved in energy release?

A. Oxygen. **B.** A source of organic material.
C. Nitrogen. **D.** Carbon dioxide. **E.** Water.

52. (1.20) Which of the following ordinarily serves as the chief source of energy used in muscular contraction?

A. Proteins. **B.** Minerals. **C.** Glucose.
D. Vitamins. **E.** Hormones.

53. (1.20) Which one of the following includes the other four?

A. Heat. **B.** Light. **C.** Energy.
D. Motion. **E.** Electricity.

54. (1.20) Which of the following terms is least closely related to the other four?

A. Element. **B.** Compound. **C.** Matter.
D. Energy. **E.** Atom.

55. (1.20) **Which of the following is a *principle* that is fundamental to the organism's utilization of matter and energy?**

A. **Only substances in solution can diffuse through the cell membrane of the protoplasm.**
B. Diffusion is the process whereby particles scatter from a region of greater concentration to one of lesser concentration.
C. The hydrolyzing process that occurs in the alimentary tract is known as digestion.
D. An enzyme is an organic catalyst.
E. None of the above is a principle.

56. (1.20) The chief value to the animal body of the breakdown of glucose to carbon dioxide and water is that it

A. satisfies the body's craving for food.
B. releases energy.
C. provides the raw materials for protein synthesis.
D. enables the body to synthesize carbohydrates.
E. contributes to the oxygen supply for the entire animal kingdom.

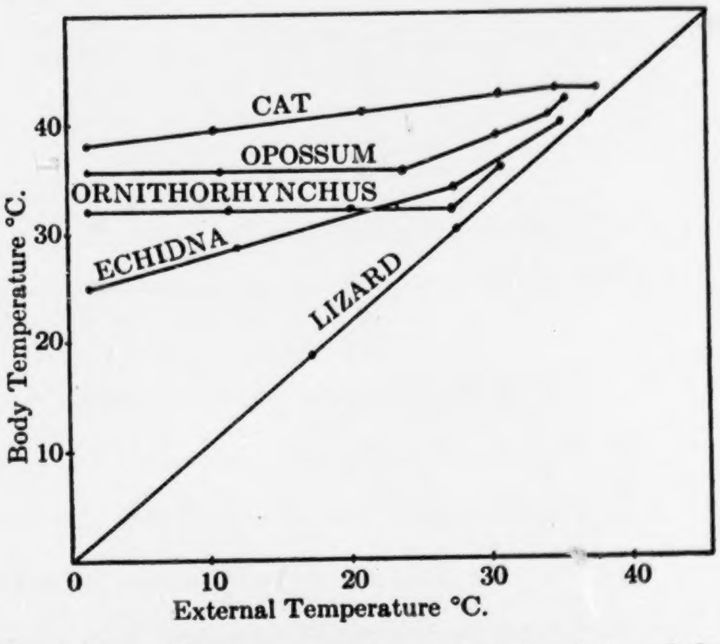
57. (1.20) When a person has been in a state of rest and has not eaten anything during the preceding 12-hour period, his energy output is most nearly proportional to his

A. height. **B.** weight. **C.** body volume.
D. body surface area. **E.** race.

58. (1.20) The class of food substances which yields the greatest amount of energy per gram when completely broken down in an organism is

A. simple carbohydrates. **B.** complex carbohydrates.
C. fats. **D.** proteins. **E.** minerals.

Problem 1—Below is a graph giving some information on variation in body temperature of different types of animals by exposure for two hours in an environment rising from 5° to 35°C. (Best and Taylor. *The Living Body.* Henry Holt and Co., 1952. P. 412.)



For each of the statements below indicate by choice of the proper number whether these data alone

A. are sufficient to make the statement true.
B. are sufficient to indicate that the statement is probably true.
C. are not sufficient to indicate whether there is any degree of truth or falsity in the statement.
D. are sufficient to indicate that the statement is probably false.
E. are sufficient to indicate that the statement is false.

59. (2.20) The body temperature of the Echidna varied more than that of the cat.

60. (2.20) There is a close correlation between the rise of body temperature of the lizard and that of the external environment.

61. (2.20) If a turtle be substituted for the lizard, there would be no essential change in the graph.

62. (2.20) The ability of the cat to maintain constant body temperature is due to its coat of hair.

63. (2.20) When the external temperature was about 23°C., the body temperature of Echidna and that of Ornithorhynchus were identical.

64. (2.20) When the external temperature is 50°C. one would expect the body temperature of a lizard to be 50°C.

65. (2.20) When the external temperature is 50°C. one would not expect the body temperature of a lizard to be as high as 50°C.

66. (2.20) When the external temperature was 25°C., the body temperature of the lizard was 25°C.

67. (2.20) The purpose of this study was to show zoologists that all animals are not alike physiologically.

68. (2.20) The heart beat of the lizard increases with the temperature in the same way that the body temperature increases.

69. (2.20) How does the statement "The energy for muscle contraction comes from the burning of glycogen" differ from the statement "The burning of glycogen causes a muscle to contract?"

A. The first statement tells the truth but not the whole truth.
B. The second statement is true and more explicit.
C. The first statement is more exact in pointing out the steps in the process.
D. No energy is involved in the process according to the second statement.
E. A scientist who had made a thorough study of body functioning would be more likely to make a statement like the second than like the first.

70. (3.00) Why does the consumption of relatively large quantities of fats by the Eskimos contribute to their ability to endure the cold climate in which they live?

A. Fat molecules contain hydrogen and oxygen in a two-to-one ratio.
B. Fat molecules are the most complex food molecules known.
C. Fats are more soluble in the blood than any other known food.
D. Molecules of fat are less oxidized than the molecules of any other class of food.
E. Fats are the best protoplasm-building foods known to man.

71. (3.00) If an individual who weighs 125 pounds climbs a stairs 15 feet long to reach the second floor which is 9 feet above the level of the first floor, how many foot-pounds of potential energy have been stored in his body?

A. $8\frac{1}{3}$. **B.** $13\frac{8}{9}$. **C.** 1125. **D.** 1875.
E. 16,875.

When on Thursday, February 8, 1951, a Chicagoan, Mrs. Dorothy Mae Stevens, was found unconscious in a passageway after a night of exposure to 11 degree subzero weather, "she was literally frozen stiff."

Her temperature had dropped to an unprecedented 64 degrees (Fahrenheit). Twenty hours after her arrival at Michael Reese Hospital, her temperature had risen to 98.2 degrees. Early Friday it was 101 and later 100. On Saturday it was also 100.

When she was first found, her respiration was slowed to 3 a minute. By Saturday it was up to 24 a minute.

Her blood pressure was zero on Thursday. By Saturday it was 132 over 80. On Thursday her pulse rate was 12 a minute; on Saturday it was 100. Cortisone was administered early.

For items 75 - 79, after each item number on the answer sheet, blacken the *one* lettered space which designates the correct answer.

72. (3.00) On Thursday Mrs. Stevens' temperature was

A. approximately 14 degrees lower than normal.
B. approximately 24 degrees lower than normal.
C. considered low, but not unusual because the temperature of man fluctuates as much as 40-50 degrees depending upon the external temperature.
D. approximately 34 degrees lower than normal.
E. approximately 44 degrees lower than normal.

73. (3.00) At a body temperature of 64 degrees

A. the blood and lymph are frozen.
B. the blood carries more oxygen to the cells than normally, because more gases dissolve in fluids at low temperatures than at high temperatures.
C. the blood vessels of the skin are dilated, because the vasoconstrictor muscles are relaxed.
D. the heart beats more rapidly, because the cold stimulates the heart center in the medulla.
E. most activities slow down, because all chemical activities decrease as the temperature falls.

74. (3.00) Under normal conditions a sharp rise in external temperature would result in

A. no bodily change.
B. dilation of blood vessels in the skin and an increase in secretion of sweat.
C. constriction of blood vessels in the skin and an increase in secretion of sweat.
D. dilation of blood vessels in the skin and a decrease in secretion of sweat.
E. constriction of blood vessels in the skin and a decrease in secretion of sweat.

75. (3.00) **Most of heat lost from Mrs. Stevens' body by radiation, conduction, or convection was brought directly to the skin by the**

A. heat receptors. **B.** blood. **C.** muscles.
D. oxidation of foods. **E.** sweat.

76. (3.00) The immediate cause of Mrs. Stevens' unconsciousness was probably due to the

A. lack of a sufficient amount of oxygen to the brain cells.
B. lowering of the external temperature.
C. slow pulse rate. **D.** decrease in muscle tone.
E. low breathing rate.

77. (3.00) **At the temperature of 64 degrees the enzymes in the body**

A. are totally ineffective, but not destroyed.
B. are more active than at higher temperatures.
C. are destroyed.

D. are not affected in any way; they cause as rapid chemical changes as at higher temperatures.
E. act more slowly than at higher temperatures.

78. Under normal conditions most of the heat lost from
(3.00) Mrs. Stevens' body would be lost by

A. elimination of urine and feces.
B. warming of foods and fluids passing along the digestive tract.
C. elimination of warmed air from the lungs.
D. warming of cold air entering the lungs.
E. evaporation of sweat and radiation and conduction of heat from the skin.

79. The immediate source of most of the heat normally
(3.00) needed for maintaining Mrs. Stevens' body temperature is the

A. contraction of muscles.
B. exchange of gases between atmosphere and lung tissue.
C. exchange of gases between blood and cells of the body.
D. heat regulating center in the brain.
E. secretion by glands.

15. Respiration

RESPIRATION

1. (1.10) The basic method of oxygen and carbon dioxide exchange in both terrestrial and aquatic animals is by

A. diaphragmatic and intercostal muscle activity.
B. oxygen debt satisfaction.
C. the pressure of the atmosphere.
D. trachial and bronchial activity.
E. diffusion through a moist cell membrane.

2. (1.10) Which of the following processes liberates carbon dioxide into the atmosphere?

A. Photosynthesis. **B.** Digestion.
C. Respiration. **D.** Symbiosis. **E.** Osmosis.

3. (1.10) About four-fifths of the energy produced by oxidation of food is used to

A. maintain the body temperature.
B. contract the muscles.
C. cause gland cells to secrete.
D. produce nerve impulses in nerve cells.
E. manufacture new cells to replace those which wear out.

4. (1.10) How is oxygen carried in tracheae?

A. In solution in body fluids.
B. In solution in blood. **C.** As a gas.
D. In loose chemical combination.

5. (1.10) Items 11 - 15, Functions.

KEY

A. Digestion. **B.** Dissimilation.
C. External Respiration. **D.** Internal Respiration.
E. Oxidation.

(1.10) To which of the above do the following correspond?

A. Exchange of carbon dioxide and oxygen between cells and blood.
B. Exchange of carbon dioxide and oxygen between lungs and blood.
C. Combination with oxygen.
D. Conversion of food into soluble substances.
E. Reduction of chemical compounds to simpler forms.

6. (1.10) Oxygen exchange of the typical terrestrial insect is effected by which of the following?

A. Diffusion through the exoskeleton.
B. Highly vascularized gills, suspended in an air sac.
C. Tracheae opening into lungs.
D. Tracheae running directly to the tissues.
E. Tracheae surrounded by a vascular network.

7. (1.10) Which of the following is said to be a carrier of respiratory enzymes?

A. Golgi Apparatus. **B.** Centriole.
C. Mitochondria. **D.** Plasmosome.

8. (1.10) The respiratory quotient of fat is

A. 1.0 **B.** 0.90 **C.** 0.80 **D.** 0.70

9. (1.20) Most of the energy liberated by respiratory activity in man is utilized by the body for

A. activation of the muscles.
B. secretion of gland cells.
C. maintenance of uniform body temperature.
D. production of nerve impulses.
E. synthesis of protoplasm.

10. (1.20) During the winter months an elm tree

A. stops respiration entirely.
B. continues respiration at the same rate as in the summer.
C. continues respiration at a lower rate than in the summer.
D. continues respiration at a faster rate than in the summer.

11. (1.20) This is partly explained by the fact that

A. photosynthesis cannot take place in the absence of leaves.
B. no food is available.
C. roots continue to take up food from the soil but at a reduced rate.
D. respiration is essential to continuation of life of all organisms.
E. a rapid rate of respiration is necessary to keep the tree from freezing.

12. (1.20) Besides carbon dioxide, another important waste product of both plant and animal respiration is

A. water. **B.** sugar. **C.** oxygen.
D. calcium. **E.** hydrochloric acid.

13. (1.20) Four of the following are characteristic of oxyhemoglobin. Which one is not?

A. It is a highly stable compound.
B. It is bright red in color.
C. It is found in higher concentration in the pulmonary veins than in the pulmonary arteries.
D. It is carried by the red corpuscles.
E. The chemical affinity between oxygen and hemoglobin is slight.

14. (1.20) Respiration in a fish is facilitated most by

A. high oxygen and low carbon dioxide concentration in the water.
B. high carbon dioxide and high oxygen concentration in the water.
C. high oxygen content in the blood of the fish.
D. high carbon dioxide content in the blood of the fish.
E. lack of movement of the water.

15. (1.20) Frogs are able to live in the stream-bottom mud all winter because

A. no oxygen is required, hence respiration ceases altogether in this quiescent stage.
B. hibernation is a stage in which metabolic activity is temporarily suspended.
C. the frogs have previously stored sufficient oxygen to last until spring.
D. the frogs respire through their skin instead of using their lungs during hibernation.
E. the kidneys take over all the excretory functions during hibernation, hence respiratory wastes are discharged by the kidneys.

16. (1.20) Which of the following is a source of carbon dioxide that is exhaled from the body?

A. Synthesis of protein from amino acids.
B. Oxidation of simple sugars.

C. Debris resulting from physical wear and tear of cells.
D. Synthesis of complex carbohydrates from simple sugars.
E. Impurities in the food that is eaten.

17. (1.20) Air enters man's lungs as a result of which of the following?

A. Suction which draws the air into the lungs.
B. A differential in air pressure, the pressure inside the lungs being lower than outside.
C. Accumulated carbon dioxide trying to get out.
D. Oxygen need by the body. E. All of the above.

18. (1.20) Which of the following is the first to break the proper sequence?

A. Larynx (voice box). B. Trachea.
C. Glottis. D. Bronchi. E. Bronchioles.

19. (1.20) Which of the following best describes what normally occurs in man's lungs?

A. The oxygen of the inspired air is completely removed by the lungs and replaced by carbon dioxide.
B. The blood filters out of the capillaries of the lungs into the lymph vessels where exchange of products occur after which the blood re-enters the lung capillaries.
C. Oxygen and carbon dioxide exchange occurs in the capillaries of the air sacs in response to differential diffusion gradients.
D. The squeezing action of the lungs in breathing is solely responsible for the oxygen-carbon dioxide exchange.
E. Scientists do not yet understand how the gaseous exchanges take place in the lungs.

20. (1.20) In the exchange of gases in the alveoli of the lungs there is evidence that

A. some gases can move through certain membranes in only one direction.
B. some gases retard the diffusion of other gases through certain membranes.
C. two different gases can be passing simultaneously in opposite directions through certain membranes.
D. gases differ in their abilities to pass through certain membranes.
E. hemoglobin has equal affinity for carbon dioxide and oxygen.

21. (1.20) When the body is functioning normally the concentration of carbon dioxide is greatest in which of the following?

A. Arterial blood approaching a cell in the foot.
B. Venous blood leaving the cell in the foot.
C. Tissue fluid surrounding the cell in the foot.
D. The interior of the cell in the foot.
E. None of the above—the concentration of CO_2 is relatively constant in all parts of the body.

22. (1.20) Respiration within the cell

A. releases energy to the organism.
B. releases oxygen as a waste product.
C. occurs only in sunlight.
D. increases the weight of the organism.
E. occurs only in animals.

23. (1.20) In the following pair, blacken space 1 if the first element of the pair is definitely greater than the second; space 2 if the second is definitely greater than the first; and space 3 if the two are approximately equal.

A. Rate of breathing in 100% oxygen.
B. Rate of breathing in 90% oxygen plus 10% carbon dioxide.

24. (1.20) In the following pair, blacken space 1 if the first element of the pair is definitely greater than the second; space 2 if the second is definitely greater than the first, and space 3 if the two are approximately equal.

A. Nitrogen concentration in inhaled air.
B. Nitrogen concentration in exhaled air.

25. (1.20) In the following pair, blacken space 1 if the first element of the pair is definitely greater than the second; space 2 if the second is definitely greater than the first; and space 3 if the two are approximately equal.

A. Concentration of oxygen in blood within the left auricle.
B. Concentration of oxygen in blood within the right auricle.

26. (1.20) In the listed pair of conditions, processes, etc., mark for each item:

Space 1 if the two increase or decrease together.
Space 2 if the one increases as the other decreases.
Space 3 if there is no relationship between the two conditions.

A. Concentration of carbon dioxide in the blood.
B. Rate of breathing.

27. (1.20) The return of carbon dioxide to the atmosphere is accomplished in the largest degree by

A. respiration of animals. B. bacterial decay.
C. combustion of fuels. D. decomposition of rocks.

28. (1.20) According to the outcome of a series of laboratory experiments, the stimulus which actuates the organs of the respiratory system is

A. oxygen shortage in the body.
B. increased heart rate.
C. increased internal temperature of the body.
D. increased water vapor in the air.
E. accumulation of CO_2 in the blood.

29. (1.20) Which of the following constitutes the most accurate statement concerning respiration in plants?

A. Respiration is a process by which plants manufacture food out of water and carbon dioxide.
B. Plants do not carry on respiration as photosynthesis is substituted for the process in plant life.
C. Respiration is a process by which plants synthesize protein.
D. Respiration is a process by which plants release energy by oxidizing carbohydrates.
E. It is the process by which plants lower their leaf temperature on hot summer days.

30. (1.20) Respiration within the cell

A. releases energy to the organism.
B. releases oxygen as a waste product.
C. occurs only in sunlight.
D. increases the weight of the organism.
E. occurs only in animals.

31. In the respiration experiment with the spirometer, the
(1.20) rate or depth of breathing, or both, were greatest with which gas mixture or condition?

A. Abundant oxygen—low carbon dioxide.
B. Moderate oxygen—low carbon dioxide.
C. Room air—low carbon dioxide.
D. After forced breathing (overventilation).
E. High oxygen—high carbon dioxide.

32. In man's external respiratory system diffusion of oxygen
(1.20) and carbon dioxide occurs primarily in the

A. alveoli. B. pharynx. C. bronchi.
D. pleural cavities. E. glottis.

33. In mammalian respiration, air enters the lungs as a
(1.20) result of

A. a series of rhythmic tracheal contractions.
B. oxygen debt accumulation.
C. a partial vacuum created by the action of the diaphragm.
D. diffusion through a moist membrane.
E. increased thoracic pressure by lengthening of the intercostal muscles.

Items 34 - 47. After each item number on the answer sheet, blacken space

A if the item refers to photosynthesis.
B if the item refers to respiration.
C if the item refers to both photosynthesis and respiration.
D if the item refers to neither photosynthesis nor respiration.

34. Occurs in both plants and animals.
(1.20)

35. Energy is released.
(1.20)

36. The ultimate source of energy is the sun.
(1.20)

37. Energy is stored. **38.** Occurs only in animals.
(1.20) (1.20)

39. Requires the presence of an enzyme.
(1.20)

40. Oxygen is released.
(1.20)

41. Carbon dioxide is one of the products.
(1.20)

42. May be represented by a chemical equation.
(1.20)

43. Must precede the synthesis of fats and proteins.
(1.20)

44. The immediate source of energy is the oxidation of
(1.20) simple sugars.

45. Occurs in all living cells.
(1.20)

46. The immediate source of energy is sunlight.
(1.20)

47. Cannot take place in man unless oxygen is transported
(1.20) by red blood cells.

48. Oxidation occurs at a relatively low temperature in living
(1.20) organisms because

A. less energy is released than in the burning of the same amount of material in air.
B. oxidation occurs more slowly in living organisms than during combustion.
C. some organisms are cold-blooded, others have a constant body temperature.
D. energy in living organisms is conducted away more rapidly.
E. enzymes facilitate the oxidation occurring in living organisms.

49. Which of the following accounts for the difference in
(1.20) temperature at which glucose is oxidized in a yeast cell and the temperature at which it is oxidized over a flame?

A. The presence of an enzyme in the yeast cell.
B. The presence of oxygen in the yeast cell.
C. The presence of carbon dioxide in the yeast cell.
D. More than one of the above.
E. None of the above.

50. As exhaled air is bubbled through Phenol Red the color
(1.20) of the solution changes to yellow. This provides evidence that

A. the body produces carbon dioxide.
B. the body produces oxygen.
C. there is carbon dioxide in the exhaled breath.
D. there is oxygen in the exhaled breath.
E. the lungs remove carbon dioxide from the blood.

The following key is for use with items 53 - 56.

KEY

A. Photosynthesis. B. Cellular respiration.
C. Both. D. Neither.

51. Water is involved.
(1.20)

52. Takes place best when the temperature is 100°C.
(1.20)

53. Energy is released.
(1.20)

54. The major source of oxygen used by living organisms
(1.20) on the earth.

55. Occur(s) in all living organisms.
(1.20)

56. Energy is stored.
(1.20)

57. Which of the following represents an *inaccurate* com-
(1.20) parison of the human respiratory system with the respiratory systems of lower animals?

A. The frog swallows air; normally man does not.
B. In man the exchange of gases occurs through tissue only one cell membrane in thickness; in lower animals the exchange takes place through thicker tissue.
C. The human lung contains elastic tissue; the lungs of some lower animals do not.
D. Neither man nor lower animals can remove the oxygen chemically combined in the water molecule.
E. In man the oxygenated blood returns to the heart before circulating through the body; in some lower animals it can go directly from the oxygenating organs through the body.

58. (1.20) In the process of respiration in a plant

A. the total weight of the plant is increased.
B. potential energy is stored in the plant.
C. chlorophyll is necessary, hence the process can occur only in green plants.
D. stored food is utilized.
E. protein is synthesized from photosynthetic carbohydrate.

59. (1.20) The rate and depth of breathing are greatest when there is present in the air being inhaled

A. abundant oxygen and little carbon dioxide.
B. a moderate amount of oxygen but little carbon dioxide.
C. a superabundance of oxygen but no carbon dioxide.
D. abundance of oxygen plus considerable more than normal carbon dioxide.
E. less oxygen than in the normal atmosphere and no carbon dioxide.

60. (1.20) In man's external respiratory system diffusion of oxygen and carbon dioxide occurs in the

A. alveoli. **B.** pharynx. **C.** bronchi.
D. pleural cavities. **E.** glottis.

61. (1.20) Cellular respiration and oxidation of organic matter have many similarities. However, they differ in which of the following respects?

A. Involvement of enzymes. **B.** Release of CO_2.
C. Utilization of O_2. **D.** Production of H_2O.
E. Release of energy.

62. (1.20) Cellular respiration can occur in living protoplasm at temperatures that are much lower than those at which combustion occurs in non-living things because

A. more oxygen is used by the protoplasm.
B. less carbon is present in protoplasm than in non-living things.
C. enzymes are present in protoplasm.
D. hormones are present in protoplasm.
E. protoplasm releases less carbon dioxide during the process of combustion than do non-living things.

63. (1.20) A lung can be emptied of most of its air by

A. closing off the corresponding nostril.
B. exhaling forcibly through the corresponding nostril.
C. cutting a hole through the trachea.
D. cutting a hole through the thoracic wall.
E. preventing breathing for five minutes.

64. (1.20) Four grams of carbohydrate and two grams of fat give

A. 15 calories. **B.** 25 calories. **C.** 35 calories.
D. 45 calories. **E.** more than 50 calories.

65. (1.20) When the frog is in air the concentration of oxygen in the musculocutaneous vein is

A. greater than **B.** less than
C. same as the concentration of oxygen in the hepatic portal vein.

66. (1.20) Heat production per unit of body surface of a child is

A. greater than **B.** less than
C. same as heat production per unit of body surface of an adult.

67. (1.20) When a frog is under water the concentration of oxygen in the pulmonary artery is

A. greater than **B.** less than
C. same as the concentration of oxygen in the pulmonary vein.

68. (1.20) The diffusion coefficient of oxygen in water is

A. greater than **B.** less than
C. same as the diffusion coefficient of oxygen in air.

69. (1.20) In a fasting individual the respiratory quotient is observed to be 0.8. What combination of foods is being burned?

A. all protein. **B.** ⅓ fat, ⅔ carbohydrate.
C. ⅔ fat, ⅓ carbohydrate.
D. ⅓ fat, ⅓ carbohydrate, ⅓ protein.

70. (1.20) The respiratory quotient may be determined by

A. dividing the number of inhalations by the number of exhalations.
B. dividing the number of exhalations by the number of inhalations.
C. dividing the carbon dioxide produced by the oxygen consumed.
D. dividing the oxygen consumed by the carbon dioxide produced.

71. (1.20) In the metabolic breakdown of glucose to yield carbon dioxide and water, most of the different reactions which represent oxidations are those in which

A. molecular oxygen is added to a carbon-containing molecule.
B. a water molecule is added to a carbon-containing molecule.
C. hydrogen atoms are removed from a carbon-containing molecule.
D. a carboxyl group is removed from a carbon-containing molecule.
E. carbon-containing molecules are split into halves.

72. (1.20) In which part of the heart of the frog does the blood contain a higher concentration of oxygen when the frog is hibernating?

A. Conus arteriosus. **B.** Left auricle.
C. Right auricle. **D.** Ventricle.

Items 73 - 77. In answering these questions refer to the following key list.

KEY

A. external respiration. **B.** tissues of the body.
C. diaphragm relaxed. **D.** breathing.
E. diaphragm contracted.

73. (1.10) What is the exchange of gases called between the air and blood in the lungs?

74. (1.10) What are the movements called which are associated with getting air in and out of the lungs?

75. (1.20) Where does the carbon dioxide of the blood come from?

76. (1.20) When the lungs are full of air, in what condition is the diaphragm found? (This position of the diaphragm is also important in expelling the fetus in childbirth.)

77. (1.20) During which condition is the diaphragm dome-shaped?

78. Respiration in plants involves a gaseous exchange which
(1.20) is unlike that in animals. This statement is

- **A.** true, because plants use CO_2 in photosynthesis.
- **B.** true, because oxygen is a by-product of plant respiration.
- **C.** false; in both plants and animals, respiration involves the combination of oxygen with energy-containing compounds.
- **D.** false, because hemoglobin, an oxygen-containing compound, is lacking in plants.
- **E.** false, because plants use carbon dioxide in respiration.

79. The amount of oxygen required for the oxidation of one
(1.20) gram of fat is

- **A.** greater than **B.** less than
- **C.** same as the amount of oxygen required for the oxidation of one gram of carbohydrate.

80. The concentration of oxygen in the pulmonary vein is
(1.20)

- **A.** greater than **B.** less than
- **C.** same as the concentration of oxygen in the pulmonary artery.

81. The most important outcome, to the living organism, of
(1.20) cellular respiration is

- **A.** energy transformation. **B.** oxygen intake.
- **C.** carbon dioxide discharge. **D.** food intake.
- **E.** none of these.

82. Carbon dioxide is released to the atmosphere by which
(1.20) of the following?

- **A.** Elm tree, geranium, corn plant.
- **B.** Mushroom, toadstool, puffball.
- **C.** Bread mold, yeast, nitrogen-fixing bacteria.
- **D.** More than one of these groups.
- **E.** None of these groups.

Items 83 - 99. After each number on the answer sheet, blacken **space**

- **A** if the item at the left of the page is of greater magnitude than the item at the right.
- **B** if the item at the right of the page is of greater magnitude than the item at the left.
- **C** if the two items are of approximately equal magnitude.

Note: The magnitude of one of the two things compared may be zero.

83. (1.20)	Amount of water absorbed in the duodenum.	....	Amount of water absorbed in the colon.
84. (1.20)	Amount of chemical digestive action in the stomach.	....	Amount of chemical digestive action in the small intestine.
85. (1.20)	Amount of acid in the pancreatic juices.	....	Amount of acid in the gastric juices.
86. (1.20)	The importance of respiration to animals.	....	The importance of respiration to plants.
87. (1.20)	Amount of starch digestion in the small intestine.	....	Amount of starch digestion in the stomach.
88. (1.20)	Amount of fat digestion in the stomach.	....	Amount of fat digestion in the duodenum.

89. (1.20)	Amount of fatty acid and glycerol formed in the intestine.	....	Amount of fatty acid and glycerol formed in the stomach.
90. (1.20)	The amount of energy required in the synthesis of one gram of glucose.	....	The amount of energy released when one gram of glucose is oxidized.
91. (1.20)	Amount of maltose formed in the mouth.	....	Amount of maltose formed in the small intestine.
92. (1.20)	Amount of amino acids formed in the stomach.	....	Amount of amino acids formed in the duodenum.
93. (1.20)	Amount of fat digested by enzymes in intestinal juices.	....	Amount of fat digested by enzymes in pancreatic juices.
94. (1.20)	The number of carbon dioxide molecules used in photosynthesis.	....	The number of glucose molecules produced in photosynthesis.
95. (1.20)	The ability of an enzyme in gastric juice to digest protein in the presence of an acid.	....	The ability of an enzyme in pancreatic juice to digest protein in the presence of an acid.
96. (1.20)	The importance of diffusion in the respiration of one-celled animals and plants.	....	The importance of diffusion in the respiration of many-celled animals and plants.
97. (1.20)	The amount of glycogen stored in the liver.	....	The amount of glycogen stored in the pancreas.
98. (1.20)	The amount of free oxygen used in photosynthesis.	....	The amount of free oxygen used in respiration.
99. (1.20)	The amount of energy stored during digestion.	....	The amount of energy stored during photosynthesis.

100. Which one of the following is a waste product when
(1.20) glucose is broken down with the liberation of energy in the body?

- **A.** Carbon dioxide (CO_2).
- **B.** Ammonium hydroxide (NH_4OH).
- **C.** Hydrochloric acid (HCl).
- **D.** An amino acid ($CH_3CH(NH_2)COOH$).
- **E.** Nitric acid (HNO_3).

101. Which of the following is a source of carbon dioxide
(1.20) which is exhaled from the body?

- **A.** Debris resulting from physical wear and tear of cells.
- **B.** Oxidation of simple sugars.
- **C.** Synthesis of protein from amino acids.
- **D.** Synthesis of complex carbohydrates from simple sugars.
- **E.** Impurities in the food that is eaten.

102. Asphyxiation from prolonged breathing of air containing
(1.20) carbon monoxide is due to which one of the following?

- **A.** Carbon dioxide release by the blood is rendered difficult.
- **B.** The muscles of the heart become paralyzed.
- **C.** The blood tends to congeal in the capillaries.

D. Oxygen is prevented from uniting with the hemoglobin.
E. Spasms of the diaphragm occur, increasing in violence with prolonged exposure.

103. In living green plants
(1.20)

A. photosynthesis takes the place of respiration.
B. photosynthesis and respiration occur constantly and simultaneously.
C. there is an alternation between the two processes, photosynthesis occurring in the daytime and respiration at night.
D. respiration occurs continuously throughout life, while photosynthesis occurs only when the requisite environmental conditions prevail.
E. carbon dioxide is utilized in respiration—while oxygen is given off—just the reverse of the respiratory situation in animals.

104. Combustion differs from cellular respiration in
(1.20)

A. that combustion produces more heat.
B. that combustion occurs at a higher temperature.
C. that combustion wastes more energy.
D. that cellular respiration is more rapid.
E. none of the above respects.

Items 105 - 112. Use the following key.

KEY

A. Iodine. **B.** Benedict's solution.
C. Phenol red. **D.** Winkler's solution.
E. Hydrochloric acid.

105. A positive test for this substance would differentiate
(1.20) between saliva and gastric juice.

106. This substance could be used to show the end product
(1.20) of the digestion of starch.

107. This substance could be used to identify tentatively the
(1.20) gaseous substance formed in photosynthesis.

108. This substance can be used to test for the presence of
(1.20) starch.

109. This substance could be used to test for one of the end
(1.20) products of respiration.

110. This substance could be used in making a preliminary
(1.20) test to determine whether or not an individual might be diabetic.

111. Which one of the following represents a diffusion gra-
(1.20) dient?

A. The blood flows rapidly through the arteries, then spreads out into the capillaries in the capillary beds, and finally moves along more slowly in the veins.
B. Oxygen passes from high level concentration in the blood through the intermediate level in the lymph, to low level in the body cells.
C. Food is acted upon successively by ptyalin in the mouth, by pepsin and rennin in the stomach, and finally by the enzymes of the small intestine.
D. Water and carbon dioxide may be changed in photosynthesis into glucose, which in turn changes to starch, which may be further transformed into cellulose.
E. A person who has fainted will likely revive faster if placed in a prone position with the head slightly lower than the feet to allow more blood to flow to the brain.

112. Which of the following is the best explanation of how
(1.20) the lungs operate in the breathing process?

A. The chest expands because the lungs are filled with air.
B. The lungs become inflated because the thoracic cavity is enlarged by the diaphragm and intercostal muscles.
C. The thorax expands because fresh oxygen is needed to supply the body requirements.
D. The lungs are filled with air because carbon dioxide directly stimulates the lungs to operate.
E. Oxygen hunger in the remote tissues of the body stimulates nerves connected with the lungs causing the lungs to expand.

113. Exchange of oxygen and carbon dioxide in the lungs
(1.20) occurs as a consequence of

A. osmosis. **B.** diffusion. **C.** filtration.
D. necessity. **E.** none of the above.

114. How does oxygen enter the cell of a flat worm (for
(1.20) example, a planarian)?

A. By osmosis. **B.** By diffusion. **C.** By gills.
D. By respiration. **E.** Through the lungs.

115. In a mammal the air and food are transported through
(1.20) a common passage in the

A. pharynx. **B.** larynx. **C.** esophagus.
D. trachea. **E.** epiglottis.

116. Expired air usually contains
(1.20)

A. approximately the same amount of nitrogen as is present in inspired air.
B. practically no oxygen.
C. less carbon dioxide than is present in inspired air.
D. less water vapor than is present in inspired air.
E. less suspended organic material than is present in inspired air.

117. Oxygen exchange of the typical terrestrial insect is
(1.20) effected by which of the following?

A. Diffusion through the exoskeleton.
B. Highly vascularized gills, suspended in an air sac.
C. Tracheae opening into lungs.
D. Tracheae running directly to the tissues.
E. Tracheae surrounded by a vascular network.

118. Internal respiration includes
(1.20)

A. exhalation. **B.** absorption of oxygen into cells.
C. inhalation. **D.** none of these.

119. A molecule of oxygen in going from an air sac to a
(1.20) capillary must pass through which of the following?

A. Blood. **B.** Vein. **C.** Lymph.
D. None of these.

120. Oxygen enters the blood because of
(1.20)

A. higher partial pressure of O_2 in lungs.
B. higher partial pressure of CO_2 in lungs.
C. higher partial pressure of O_2 in blood.
D. because blood contains hemoglobin.

121. For flying at 30,000 feet it is necessary to supply nearly
(2.20) pure oxygen to the occupants of the plane. Usually a small amount of CO_2 is added to the oxygen. Why is this done?

A. The CO_2 is used to partially dilute the oxygen—breathing pure oxygen will tend to cause a burning sensation in the chest.
B. A small amount of CO_2 is used in cellular respiration.
C. CO_2 is used in the formation of carbonic acid which is essential in certain reactions.
D. CO_2 stimulates the respiratory center in the medulla.
E. CO_2 is used in carbohydrate synthesis.

Items 122 and 123 are based upon the following quotation:

"Air possesses a certain occult virtue. . . . In this virtue the secret food of life is hidden. . . . Happy the man who will discover it!" Hermann Boerhaave—*Elements of Chemistry.* 1716.

122. The "occult virtue" referred to in the quotation is in all
(2.20) probability

A. hydrogen. **B.** nitrogen. **C.** carbon dioxide.
D. oxygen. **E.** kinetic energy.

123. The "occult virtue" is most likely
(2.20)

A. an element. **B.** a compound. **C.** a mixture.
D. a molecule. **E.** none of the above.

Some sprouted, growing seedlings were placed on a damp blotter in a bottle. The bottle was connected with a test tube of lime water by means of a glass tube. A control experiment was arranged with another bottle, exactly like the first except that the seedlings had been killed with chemicals. After several hours the test tubes of lime water were observed. The one connected with the bottle of germinating seeds had become cloudy; the other remained clear. (Item 124)

124. Which of the following constitutes the best explanation
(2.20) of these results?

A. Plants differ from animals in that they use carbon dioxide instead of oxygen in respiration.
B. Only plants containing chlorophyll could have produced these results.
C. Lime water tests for the presence of oxygen.
D. Plants, like animals, release carbon dioxide during respiration.
E. Photosynthesis occurs only in the presence of light.

Each of items 125 - 126 begins with the specification of some structure, condition, or process. After the exercise number on the answer sheet blacken the *one* lettered space which designates the *most* similar structure, condition, or process.

125. The essential process of respiration:
(2.20)

A. The rolling of a stone down a hill.
B. The diffusion of a substance through a permeable membrane.
C. A reaction in which simple molecules combine to form complex molecules.
D. The burning of a fire.
E. The transportation of nutriment in a plant.

126. The mechanics of inhalation in man:
(2.20)

A. Releasing the pressure on a squeezed hollow rubber ball that has a hole in it.
B. Inflating an automobile tire.
C. Blowing soap bubbles.
D. Squeezing a hollow rubber ball that has a hole in it.
E. Moving a pump handle up and down.

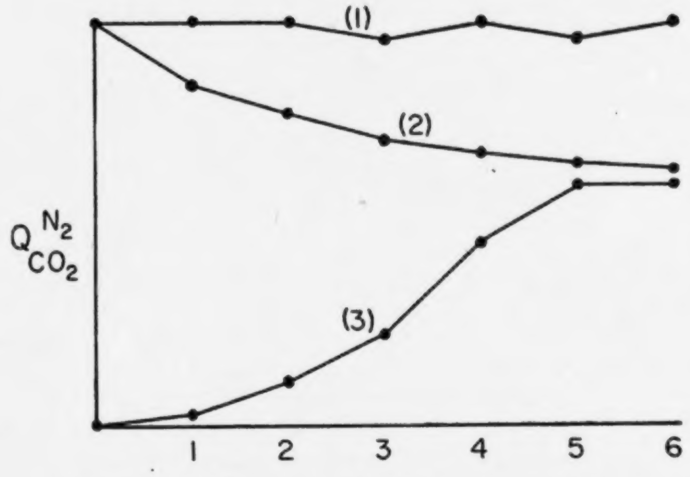
127. The amount of galactozymase is determined by the
(2.20) following procedure:

A. Measure the CO_2 produced per "unit" of yeast incubated in galactose.
B. Remove cells from time to time from a clone bathed in galactose and determine their chemical make-up after the usual centrifuging technique.
C. Remove galactozymase from yeast cells; put it into a sugar medium and measure the rate at which the sugar is metabolized to alcohol.
D. Measure the rate at which yeast cells reproduce in an environment lacking galactozymase.
E. Measure the amount of galactose that is produced by yeast cells immersed in distilled water in the absence of nitrogen.

128. The conclusion that "enzyme formation is governed by
(2.20) an autosynthetic reaction" is an interpretation of the empirical relation between enzyme activity and

A. time.
B. amount of protein precursor used by the cell.
C. total amount of yeast cells.
D. activity of the appropriate nuclear gene.
E. transfer of phosphate from the nucleo protein fraction.

In order to determine the source of protein in the synthesis of enzymes, Spiegelman reports experiments on the interaction of enzyme systems. For items 129 - 133, consider the data on the effect of adaptation to galactose on glucozymase.



Curve (1) is glucozymase in unadapting control;
Curve (2) is glucozymase during adaptation to galactose;
Curve (3) shows the appearance of galactozymase.

129. From the data it is clear that all of the yeast which is to
(2.20) be the material for the experiment has been living for a considerable time in a minimal inorganic medium

A. plus galactose. **B.** plus glucose.
C. plus galactose and glucose mixed in equal proportions.
D. with no source of carbohydrates.

130. The first step of the experiment consists of dividing the
(2.20) clone into experimental and control parts. The experimental part is placed in a minimal inorganic medium plus

A. galactose. **B.** glucose.
C. galactose and glucose mixed in equal proportions.
D. with no source of carbohydrates.

131. (2.20) Curve (1) is obtained by measuring respiration in

- **A.** samples of yeast placed in galactose—the samples having been taken every hour from the yeast living in glucose.
- **B.** samples of yeast placed in glucose—the samples having been taken every hour from the yeast living in galactose.
- **C.** samples of yeast placed in the mixture of galactose and glucose—the samples having been taken every hour from the "control yeast."
- **D.** samples of yeast placed in glucose—the samples having been taken every hour from the yeast living in the mixture of galactose and glucose.
- **E.** yeast which has been living continuously in glucose from the start of the experiment.

132. (2.20) Curve (2) is obtained by measuring respiration in

- **A.** samples of yeast placed in galactose—the samples having been taken every hour from the yeast living in glucose.
- **B.** samples of yeast placed in glucose—the samples having been taken every hour from the yeast living in galactose.
- **C.** samples of yeast placed in the mixture of galactose and glucose—the samples having been taken every hour from the "experimental yeast."
- **D.** samples of yeast placed in galactose—the samples having been taken every hour from the yeast living in the mixture of galactose and glucose.
- **E.** yeast which has been living continuously in galactose from the start of the experiment.

133. (2.20) The effect of adaptation to galactose on glucozymase is revealed by the difference between curves.

A. (1) and (2) **B.** (1) and (3) **C.** (2) and (3)

134. (2.20) Spiegelman's chief conclusion (chief in the sense of most important for the whole argument) as to the source of energy in enzyme synthesis is as follows: the energy necessary for synthesis of enzymes comes from

- **A.** an external source, so the peculiar character of a cell is a function of the environment.
- **B.** ATP or other sources of phosphate-bond energy, so that protein synthesis cannot be separated from carbohydrate metabolism.
- **C.** nucleo protein and thus from the nucleus; on the other hand, the source of material for enzyme synthesis comes from the cytoplasm.
- **D.** the molecular structure of the reactants, so that the problem of the source of energy is not separate from the problem of the source of material.
- **E.** enzymes themselves, so that the more enzymes formed the more will be formed.

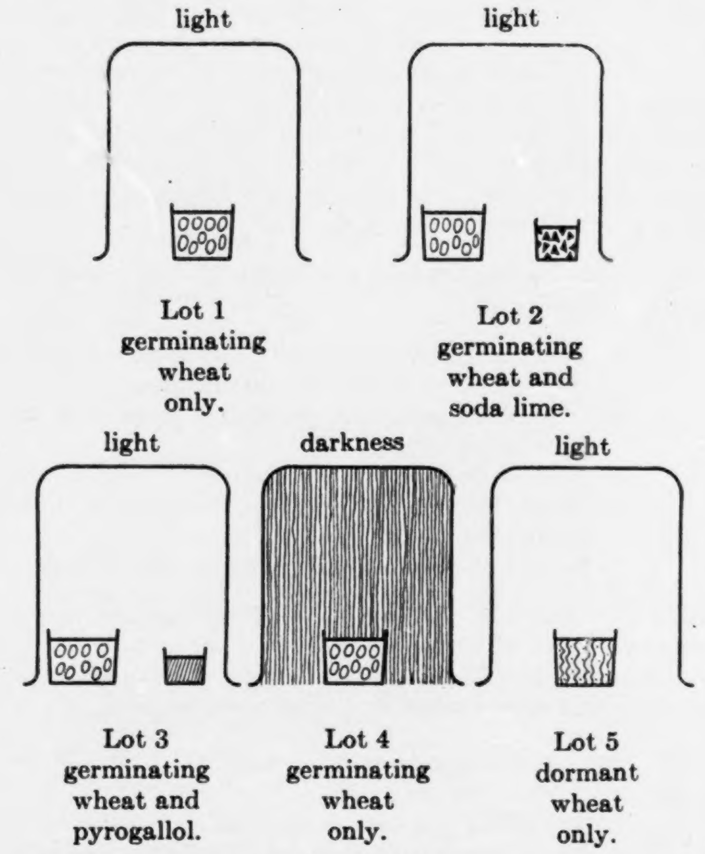
135. (2.20) Competition between metabolic systems is suggested by Spiegelman's empirical findings. This competition should be deduced without the data on enzymatic adaptation if it were known that

- **A.** all enzyme formation depends on the existence of other enzymes.
- **B.** the same kinds of substances—amino acids—constitute the building blocks of all enzymes.
- **C.** each enzyme tends to reproduce at a geometric rate, while the materials for synthesis are limited.
- **D.** each metabolic system is dependent on a single gene which has been the object of selection over a number of generations.
- **E.** each metabolic system produces a particular character or trait which is more or less viable than an alternative trait.

136. (2.20) Read the following quotation. "Three vacuum bottles have been set up containing (1) germinating wheat, (2) dead wheat, and (3) no wheat. The dead wheat has been boiled and phenol added to prevent the growth of bacteria and molds." If the phenol had not been added to the dead wheat it is probable that in three days' time

- **A.** the temperature in bottle #2 would have been the same as that in bottle #3.
- **B.** the temperature in bottle #2 would have been higher than that in bottle #3.
- **C.** there would have been no change in the temperature inside of bottle #2.
- **D.** the wheat in bottle #2 would have germinated and ruined the results of the experiment.
- **E.** There has been no evidence presented in the course that would in any way aid in the solution of this problem.

Items 137 - 141. One hundred grams of living wheat seeds are divided into five lots of 20 grams each and placed in separate beakers. Four of the lots are then treated so as to induce germination, while the fifth lot is allowed to remain dormant. Each lot is then exposed to distinct environmental conditions as shown in the diagram below.



Assume that the bell jars are of glass and that their lower edges are sealed adequately to prevent leakage of air. Assume also that the pyrogallol and the soda lime are in sufficient amounts to remove from the air all the gas to which they are sensitive.

On the basis of the above data and your understanding of biological principles, you are to answer the following items:

137. (2.20) Under the conditions here described, the seeds that would live the longest are those of

A. lot 1. **B.** lot 2. **C.** lot 3. **D.** lot 4. **E.** lot 5.

138. (2.20) Neither cellular respiration nor photosynthesis will occur under the bell jar in

A. lot 1. **B.** lot 2. **C.** lot 3. **D.** lot 4.
E. lot 5.

139. (2.20) Which two of the lots might be chosen as an experiment to test the hypothesis that "Life ceases in the absence of cellular respiration"?

A. Lots 2 and 3. **B.** Lots 1 and 3.
C. Lots 4 and 5. **D.** Lots 1 and 2.
E. None of the above.

140. (2.20) Differences in the results of which two lots might be attributed to the fact that enzymes are able to bring about their reactions only in a watery medium?

A. Lots 3 and 5. **B.** Lots 2 and 3.
C. Lots 1 and 3. **D.** Lots 3 and 4.
E. None of the above.

141. (2.20) The differences between the results of Lot 1 and Lot 2 might be used as support for which one of the following generalizations?

A. Carbon dioxide is necessary for photosynthesis.
B. Water is the medium in which all life processes occur.
C. Cellular respiration occurs day and night, in all organisms.
D. Light is necessary for photosynthesis.
E. None of the above four statements is supported by the results of Lots 1 and 2.

142. (2.20) The substance which is produced copiously by metabolic processes in the vertebrate body in the absence of sufficient oxygen, but not in the presence of sufficient oxygen, is

A. carbon dioxide. **B.** ATP. **C.** lactic acid.
D. citric acid. **E.** hydrogenated coenzyme I.

143. (2.20) Coenzyme I is oxidized (dehydrogenated) by reactions. (Give the alternative which includes all the correct reactions and none of the incorrect reactions.)

A. G. **B.** Q, S, and V. **C.** G, Q, S, and V.
D. L and W. **E.** G, L, Q, S, V, and W.

144. (2.20) The product(s) of the energy-yielding breakdown of glucose in yeast cells in the absence of ample oxygen is (are)

A. carbon dioxide and water. **B.** lactic acid.
C. alcohol and carbon dioxide.
D. pyruvic acid and water.
E. acetic acid and carbon dioxide.

145. (3.00) The simplest method of determining the favorableness of a given set of environmental circumstances for yeast metabolism would be to measure

A. the content per yeast cell of the enzymes succinic dehydrogenase and cytochrome oxidase.
B. the rate of increase in number of yeast cells.
C. the concentrations of the various end-products of yeast metabolism after the lapse of a definite time.
D. the quantity of ATP per yeast cell.
E. the oxygen concentration of the medium.

146. (2.30) A reaction which would be blocked in the absence of free ATP in the cell would be

A. A. **B.** F. **C.** H. **D.** Q. **E.** W.

147. (2.20) The carbon dioxide produced by the combustion of glucose is produced in reactions

A. A through G. **B.** A through L.
C. M through V. **D.** W through X.
E. A through L and W through X.

148. (2.30) The hydrogen atoms involved in reactions W and X are removed from breakdown products of glucose in reactions. (Give the alternative which includes all the correct reactions and none of the incorrect.)

A. G and L. **B.** Q, S, and V. **C.** J, O, and P.
D. G, Q, S, and V. **E.** G, M, Q, S, T, and V.

149. (2.20) Placing a live mouse near but not touching a piece of dry ice in a jar has which of the following effects on the mouse?

A. The mouse immediately breathes more slowly.
B. The mouse is dead within fifteen seconds.
C. The mouse is attracted to the dry ice and tries to stay as near to it as possible.
D. The mouse's breathing rate is accelerated at first, then the mouse stops breathing.
E. Nothing unusual happens.

150. (2.20) Which of the following accounts for the difference in temperature at which glucose is oxidized in a yeast cell and the temperature at which it is oxidized over a flame?

A. The presence of an enzyme in the yeast cell.
B. The presence of oxygen in the yeast cell.
C. The presence of carbon dioxide in the yeast cell.
D. More than one of the above.
E. None of the above.

151. (2.20) As exhaled air is bubbled through phenol red the color of the solution changes to yellow. This provides evidence that

A. the body produces carbon dioxide.
B. the body produces oxygen.
C. there is carbon dioxide in the exhaled breath.
D. there is oxygen in the exhaled breath.
E. the lungs remove carbon dioxide from the blood.

152. (2.20) Of what significance is it that the vital capacity of the lungs is considerably larger than the tidal air volume alone?

A. The tidal air volume is subject to considerable permanent increase, whereas the vital capacity is relatively fixed for each individual.
B. The vital capacity is the amount of breath taken in at each inspiration and must be larger than the amount that remains between breaths, otherwise the lungs would become logged with stagnant air.
C. The tidal air is used up in cellular respiration immediately upon entry into the lungs.
D. The lung capacity is relatively constant for each individual throughout life; it is important, therefore, that the vital capacity or normal depth of each breath be relatively large and more than just barely adequate to supply the body requirements.
E. Cellular respiration is a continuous process. If the vital capacity were the same or nearly the same as the normal tidal air volume, cellular respiration would become intermittent at a time of exertion, such as when running or climbing a steep hill.

153. (2.20) If his laryngeal cords were destroyed by a disease, what would be the most apparent effect on the individual?

A. He would be unable to swallow.
B. He would be unable to breathe.
C. He would suffer frequent hemorrhages.
D. He would be unable to speak.
E. His sense of equilibrium would be lost.

154. (2.30) As the *net* result of the entire course of glycolysis proper, for every glucose molecule, entering the series of reactions,

A. two ATP molecules will be produced.
B. two ATP molecules will be used up.
C. four ATP molecules will be produced.
D. four ATP molecules will be used up.
E. as many ATP molecules will be used as produced.

155. (2.30) The fluid portion of cytoplasm, from which all granules have been removed by high-speed centrifugation, is capable of oxidizing glucose as far as

A. pyruvic or acetic acid, but no farther.
B. carbon dioxide, but not water.
C. fructose, but no farther.
D. carbon dioxide and water.
E. none of the foregoing, since other components of protoplasm must be present for any glucose oxidation to occur.

156. (3.00) The temperatures inside four stoppered thermos bottles containing, respectively, (1) germinated wheat, (2) dormant wheat, (3) dead wheat, and (4) no wheat, were recorded after the bottles had stood for a week. In which bottle could one expect to find the temperature to be the highest?

A. In bottle No. 1. **B.** In bottle No. 2.
C. In bottle No. 3. **D.** In bottle No. 4.
E. The temperature would likely be the same in all the bottles.

157. (3.00) About 10 drops of phenol red are placed in a small vial and a brass screw is dropped into the vial. A piece of fresh green geranium leaf is rolled up and slid into the vial above the screw, after which the vial is stoppered. Within a few minutes the phenol red has turned yellow in color. This is an indication that

A. the leaf is giving off oxygen.
B. photosynthesis is taking place.
C. cellular respiration is occurring.
D. nitrogenous wastes are being discharged.
E. some of the chlorophyll has been dissolved by the phenol red.

158. (3.00) A sample of water (Jar A) in which six goldfish had been crowded together for an hour was subjected to the Winkler test with the result that a whitish precipitate was formed. Another sample of the same kind of water (Jar B), in which there had been no fish, yielded a brownish yellow precipitate when tested by means of the Winkler test. These data indicate that

A. there was less oxygen in the water of Jar A than in Jar B.
B. oxygen was present in the water of Jar A but lacking in Jar B.
C. carbon dioxide was lacking in the water of Jar A but was present in Jar B.
D. carbon dioxide was present in the water of Jar A but was lacking in Jar B.
E. nitrogenous wastes were present in the water of Jar A but were absent in Jar B.

159. (3.00) The results in item 158 provide circumstantial evidence that

A. there has been some kidney functioning.
B. some oxygen has been utilized in cellular respiration.
C. some carbon dioxide has been discharged in cellular respiration.
D. some carbon dioxide has been utilized in making glucose.
E. some oxygen has been discharged as a consequence of the occurrence of metabolic activity.

160. (3.00) Germinating barley seedlings placed over a dark brown solution of sodium pyrogallate in a closed vessel (A) failed to continue normal development while control seedlings placed over water in another closed vessel (B) proceeded to develop normally. This experiment demonstrates that

A. chlorophyll is changed to starch during seed germination.
B. oxygen is required in the process of seed germination and growth.
C. oxygen and water are the raw materials in photosynthesis.
D. chlorophyll is a fluorescent substance which turns dark in color upon exposure to light.
E. CO_2 is given off when seeds germinate.

161. (3.00) Some growing seedlings were placed on a damp blotter in a bottle labelled A. The bottle was connected with a test tube of lime water by means of a glass tube. A control experiment was arranged with another bottle labelled B, exactly like the first except that the seedlings had been immersed in boiling water for 30 minutes. After several hours the test tubes of lime water were observed. The one connected with bottle A had become cloudy, the other remained clear.

Which of the following constitutes the best explanation of these results?

A. Plants differ from animals in that they use carbon dioxide instead of oxygen in respiration.
B. Only plants containing chlorophyll could have produced these results.
C. Lime water is a test for the presence of oxygen.
D. Plants, like animals, release carbon dioxide during respiration.
E. There is a positive correlation between the respiratory rate and temperature from the freezing point to the boiling point of water.

162. (3.00) The greatest depth and rate of breathing would probably occur in a human subject lying down on a couch in a small closed room where there is

A. a much higher oxygen percentage and a much lower carbon dioxide percentage than in the normal atmosphere.
B. an atmosphere of nearly pure oxygen maintained from a supply tank; the carbon dioxide produced by the subject being removed by his exhaling through a tube leading outside the room.
C. the same concentration of oxygen as in the normal atmosphere, the carbon dioxide removed as it is exhaled.

D. an oxygen concentration 5% less than in the normal atmosphere; the carbon dioxide removed as it is exhaled.

E. an oxygen concentration 10% higher than in the normal atmosphere, the carbon dioxide concentration 2% higher than in the normal atmosphere.

Experiment A: A normal person is seated inside a small airtight chamber in which the air at the start of the experiment has a temperature of 72°F. and a relative humidity of 60. By means of a mask and pipes the person breathes air drawn in from outside the chamber and the air is exhaled and also passed out of the chamber.

Experiment B: The same person is later seated outside of the same chamber, but by means of the mask and pipes breathes air drawn from the chamber and the air he exhales is also passed into the chamber. The composition of the air, air pressure, temperature, and humidity were the same outside and inside the chamber at the start of each of the experiments.

Items 163 - 172. After each item number on the answer sheet, blacken space

A if the statement applies to Experiment A.
B if the statement applies to Experiment B.
C if the statement applies to neither Experiment A nor Experiment B.

163. The rate and depth of breathing increases more rapidly
(3.00) in this experiment than in the other experiment.

164. Sweating increases more rapidly in this experiment than
(3.00) in the other experiment.

165. The O_2 concentration of the air in the chamber increases
(3.00) appreciably.

166. The moisture content and temperature of the air in the
(3.00) chamber increases more rapidly in this experiment than in the other experiment.

167. The CO_2 concentration of the air in the chamber in-
(3.00) creases appreciably.

168. The number of impulses passing through the vagus
(3.00) nerves in a given unit of time increases considerably.

169. The percentage of heat loss through evaporation de-
(3.00) creases greatly.

170. The activity of the respiratory center of the medulla
(3.00) increases considerably.

171. The activity of the respiratory center of the medulla
(3.00) decreases considerably.

172. The number of impulses passing through the phrenic
(3.00) nerves in a given unit of time increases considerably.

Three breakers of equal weight, each containing five hundred grams of wheat were treated as follows: In breaker No. 1 the wheat seeds were killed by steaming. In breaker No. 2 the wheat was soaked in water, allowed to germinate, and kept in the dark for ten days. In breaker No. 3 the wheat was untreated. At the end of the ten day period all three samples of wheat were oven-dried till all water was removed, then cooled and weighed. Note: Wheat contains large amounts of starch which is readily converted to glucose. Weight of each sample after drying was as follows:

Sample No. 1	475 grams.
Sample No. 2	420 grams.
Sample No. 3	474 grams.

173. Which sample is a control for the other two samples in
(3.00) the above experiment?

A. Sample No. 1. **B.** Sample No. 2.
C. Sample No. 3. **D.** Any one of the three samples.
E. Either Sample No. 1 or Sample No. 3.

174. In the above situation, the variable factor between the
(3.00) two experimental samples and the one control sample is—

A. the percentage of starch at the beginning of the experiment.
B. the occurrence of cellular respiration during the experiment.
C. the occurrence of weight loss resulting from drying.
D. the amount of oxygen consumed during the experiment.
E. the amount of heat needed to dry the three samples.

175. On the basis of data given above one might logically
(3.00) infer that

A. the wheat in the three samples contains different amounts of respiratory enzymes.
B. all wheat samples, dead or alive, lose weight during storage.
C. loss in weight can be attributed to the using up of glucose.
D. loss in weight is due entirely to the evaporation of water.
E. cellular respiration occurs in all organisms at all times.

176. Assuming that answer number D in the previous item is
(3.00) correct, one might reasonably predict that

A. a 1000-gram wheat sample, after drying, would weigh 975 grams.
B. the wheat in Sample No. 1 would have lost 25 grams weight even if it had not been killed.
C. there should be more of a difference in weight between Samples 2 and 3 than is shown in the data.
D. Barley seeds would lose the same amount of weight as wheat seeds.
E. there would be an appreciable difference in temperature between the wheat in the three samples during the experiment.

177. The large amount of carbon dioxide that is produced
(3.00) during vigorous exercise changes to carbonic acid. The blood under these conditions would

A. naturally become acid until the exercise ceased.
B. be neutral to slightly alkaline because of the action of buffer salts.
C. be strongly alkaline because all tissues of the body change acid to alkaline and vice versa.
D. be strongly alkaline in reaction because the blood is normally highly alkaline.
E. naturally be acid because the blood is normally acid.

178. In some babies a connection between the right pul-
(3.00) monary artery and the aorta persists after birth. This would result in

A. a more efficient aeration of blood in the lungs.
B. no serious effects. **C.** high blood pressure.
D. mixing of aerated and non-aerated blood.
E. swelling of the body due to an accumulation of fluid in the tissues.

Items 179 - 184 are based upon the following experiment.

A thermos bottle was half filled with a mixture of yeast, corn syrup, and water at a temperature of 77 degrees Fahrenheit. It was then stoppered with a cotton plug through which a thermometer had been inserted. The experimental set-up was allowed to stand for 30 hours after which it was examined and certain data recorded. The following items are concerned with these data obtained after the 30 hours had elapsed.

179. The temperature inside the thermos bottle
(3.00)

A. had increased. **B.** remained the same.
C. had decreased.

180. The total amount of sugar in the mixture inside the flask
(3.00)

A. remained the same. **B.** had increased.
C. had decreased.

181. The atmosphere inside the flask
(3.00)

A. had increased in carbon dioxide content.
B. had increased in oxygen content.
C. had increased in nitrogen content.
D. had decreased in nitrogen content.
E. remained the same in composition.

182. The total weight of the contents of the thermos bottle
(3.00)

A. had increased appreciably.
B. remained the same.
C. had decreased appreciably.

183. The total amount of water in the flask after the 30 hours
(3.00)

A. was less than the original amount.
B. was slightly greater than the original amount.
C. remained the same as the original amount.

184. The initial temperature of 77 degrees Fahrenheit would
(3.00) be equivalent to

A. 109°C. **B.** 42 7/9°C. **C.** 45°C.
D. 37.5°C. **E.** 25°C.

185. Man is able to breathe with his mouth open, but a frog
(3.00) will perish if compelled to keep its mouth open for any considerable length of time. This is explained by the fact that

A. the metabolic rate is higher in the frog.
B. oxygen debt accumulation is greater in man.
C. mammals breathe by means of a series of rhythmic tracheal contractions.
D. in mammals a partial vacuum is created in the thorax by diaphragmatic action.
E. when the intercostal muscles in mammals elongate they create increased thoracic pressure.

186. A quart thermos bottle was opened long enough to
(3.00) allow a thermometer within it to indicate room temperature. Fifty flies that had been in the same room for several hours were then placed in the bottle and the bottle closed with a thick plug of heat-insulating glass wool. Assuming no change in room temperature after 30 minutes one would expect the thermometer to read

A. the same as before. **B.** a little lower than before.
C. a little higher than before.

187. Which of the following statements is most significant
(3.00) in answering the item correctly?

A. The flies remained alive.
B. Flies are cold-blooded and cause the temperature to drop.
C. Thermos bottles are more effective in keeping things cold.
D. Flies are cold-blooded and, hence, maintain the same temperature as that of their environment.

188. All substances whose complete oxidation in the typical
(3.00) cell yields energy for cell functions are oxidized via

A. either glycolysis *or* the Krebs cycle, but not both.
B. both the glycolytic and the Krebs cycle enzymes.
C. the glycolytic enzymes.
D. the Krebs cycle enzymes.
E. direct reaction with molecular oxygen.

189. An individual breathes and rebreathes the air in a large
(3.00) rubber balloon through a carbon dioxide absorber. His breathing rate does not increase very markedly during the second and third minutes. This tends to eliminate which of the following as a stimulus to the respiratory center?

A. Oxygen shortage.
B. Carbon dioxide accumulation.
C. Nitrogen accumulation.
D. More than one of the above.
E. None of the above.

190. The individual after having performed the experiment
(3.00) in which he breathed into the balloon through the carbon dioxide absorber (mentioned in the previous item) repeated the experiment by breathing directly into and out of the balloon for three minutes *without* using the carbon dioxide absorber. His breathing rate showed a marked increase each succeeding minute. The results of the two experiments together justify which one of the following conclusions?

A. Oxygen shortage stimulates us to breathe.
B. Nitrogen shortage probably activates the respiratory center.
C. Carbon dioxide accumulation may be the stimulus which makes us breathe.
D. We breathe because we need air.
E. More than one of the above serve to stimulate the respiratory center.

191. Pyrogallol placed in a breaker inside a container of
(3.00) germinating seeds quickly arrested further growth while control seeds in another container developed into normal seedlings. The effect produced by the pyrogallol can be explained by the fact that

A. photosynthesis could not occur.
B. the seedlings were deprived of moisture.
C. respiration could not occur.
D. it killed the nitrogen-fixing bacteria on the young roots of the tiny white seedlings.
E. no explanation is possible—the seeds should have continued to germinate.

Items 192 - 202.

Hypothesis: Carbon dioxide (CO_2) is a more potent factor in the control of breathing than oxygen (O_2).

Experiment: **If air from a small closed chamber is breathed and rebreathed, and care is taken to remove all the expired CO_2, the O_2 of the chamber will gradually be used up. The concentration of O_2 in the blood gradually diminishes, with no appreciable change in the blood CO_2 concentration. In such an experiment, breathing is accelerated relatively little even though the experiment is carried to the point where the O_2 content of the blood is considerably reduced.**

However, if the same experiment is repeated except that the expired CO_2 is not removed from the system but is allowed to accumulate to be rebreathed again and again, a very marked acceleration of respiration as well as extreme discomfort ("air hunger"), will result. In this experiment O_2 is being depleted from the blood as before, but CO_2 is accumulating.

Finally, if an individual breathes air containing the normal, or even more than the normal, percentage of O_2, but containing only a slight excess of CO_2, respiration will again be accelerated. Here the O_2 concentration of the blood has been maintained practically unchanged, and the CO_2 content has increased.

After the item number of the answer sheet which corresponds to that of each statement blacken space.

A if the statement supports the hypothesis, and this support is justified by the experimental data given.
B if the statement supports the hypothesis, but this support is *not* justified by the experimental data given.
C if the statement contradicts the hypothesis, and this contradiction is justified by the experimental data given.
D if the statement contradicts the hypothesis, but this contradiction is *not* justified by the experimental data given.
E if the statement is not relevant to the hypothesis.

192. (4.20) An increase of one per cent in the concentration of oxygen in the air breathed has more effect on the rate of breathing than an increase of one per cent in the concentration of carbon dioxide.

193. (4.20) Reducing the concentration of oxygen in the air breathed has less effect on the rate of breathing than increasing the concentration of carbon dioxide.

194. (4.20) Carbon monoxide combines with hemoglobin of the blood, while carbon dioxide does not.

195. (4.20) Because increased concentration of carbon dioxide in the blood prevents the blood from absorbing as much oxygen from the air as it normally should, breathing is accelerated.

196. (4.20) Holding the concentration of carbon dioxide in the blood constant while decreasing the concentration of oxygen results in a slight increase in the rate of breathing.

197. (4.20) The cells of the body require oxygen, but carbon dioxide is only a waste product of cell respiration.

198. (4.20) Since breathing soon ceases in air containing no oxygen, even though the normal amount of carbon dioxide is present, oxygen is a more potent factor than carbon dioxide in the control of breathing.

199. (4.20) Since a lack of oxygen in the blood is known to stimulate the production of red blood cells, oxygen is a more potent factor in control of breathing than carbon dioxide.

200. (4.20) Ordinary air contains about 21 per cent of oxygen but only .04 per cent of carbon dioxide.

201. (4.20) One breathes more rapidly up in the mountains where the air is more rarefied, because of the decreased concentration of oxygen even though the carbon dioxide in the air is also less concentrated.

202. (4.20) In serious cases of pneumonia, patients are placed in oxygen tents to promote respiration; but no effort is made to supply the patients with carbon dioxide.

Items 203 - 205. After the item number on the answer sheet which corresponds to that of each conclusion blacken space

A if you believe that this conclusion is the most acceptable of the three conclusions.
B if you believe that this conclusion is the least acceptable of the three conclusions.
C if you believe that this conclusion is neither the most acceptable nor the least acceptable of the three conclusions.

203. (4.20) One should hesitate to accept the hypothesis since no explanation is given with respect to why the carbon dioxide influences the rate of breathing. This aspect of the matter is worth investigating.

204. (4.20) The experiment shows that decrease of oxygen is less potent a factor in controlling the rate of breathing than carbon dioxide.

205. (4.20) The hypothesis can only tentatively be accepted until the effect of decreasing the concentration of carbon dioxide is compared with decreasing the concentration of oxygen.

16. *Excretion*

EXCRETION

1. The glomeruli are most closely related to the system
(1.10) involved in

A. digestion. **B.** excretion. **C.** reproduction.
D. reaction to stimuli. **E.** support and movement.

2. The renal corpuscle (Malpighian body) is composed of
(1.10)

A. Bowman's capsule and glomerulus.
B. renal tubule. **C.** ureter. **D.** loop of Henle.

3. The maximum size of molecules, or particles, passing
(1.10) into Bowman's capsule is best indicated, in the healthy man, as at least as large as

A. salt ions, but smaller than glucose.
B. glucose, but smaller than the amino acids.
C. the amino acids, but smaller than proteins.
D. the proteins, but smaller than blood platelets.
E. blood platelets, but smaller than red blood corpuscles.

4. Movement of fluids from arterial blood into the space
(1.10) of Bowman's capsule, in the kidney, is achieved exclusively or mainly by

A. absorption. **B.** diffusion. **C.** filtration.
D. osmosis. **E.** secretion.

5. Urea is mainly excreted from the body by
(1.10)

A. skin. **B.** lungs. **C.** kidneys. **D.** liver.

6. Glucose is excreted from the blood when above which
(1.10) of the following concentrations?

A. 0.05%. **B.** 0.1%. **C.** 0.14%. **D.** 0.10%.

7. The elimination of metabolic wastes from the body is
(1.10) called

A. egestion. **B.** oxidation. **C.** assimilation.
D. excretion.

8. The elimination of undigested materials from the body
(1.10) is known as

A. absorption. **B.** excretion. **C.** secretion.
D. egestion.

9. The organ within which the proportions of the in-
(1.10) organic salts in the blood is regulated is the

A. kidney. **B.** liver. **C.** parathyroid.
D. adrenal cortex. **E.** wall of the small intestine.

10. It is believed that contractile vacuoles serve mainly to
(1.10)

A. discharge nitrogenous wastes. **B.** digest food.
C. transport non-digestible materials in an anal pore.
D. regulate water content.
E. aid respiration, mainly by the discharge of CO_2.

11. Which one of the following would not be considered
(1.10) a metabolic waste product in plants?

A. Anthocyanin. **B.** Resins. **C.** Gums.
D. Essential oils. **E.** Glucose.

12. The most important function of perspiration is to
(1.20)

A. get rid of body poisons.
B. regulate the body water supply.
C. regulate the body temperature.
D. keep the pores clear of dirt.
E. lubricate the epithelial cells.

13. The liquid which collects in the cavity of Bowman's
(1.20) capsule is

A. urine in concentrated form.
B. freshly aerated blood.
C. blood plasma minus the plasma proteins.
D. used bile ready to be excreted.
E. adrenalin secreted by the adrenal glands located adjacent to the kidneys.

14. Indicate which is the correct sequence of the path of
(1.20) excretory wastes in man from the body to the outside:

A. bladder.
  blood.
  kidney.
  ureter.
  urethra.

B. blood.
  kidney.
  urethra.
  bladder.
  ureter.

C. blood.
  bladder.
  urethra.
  kidney.
  ureter.

D. blood
  kidney.
  ureter.
  bladder.
  urethra.

E. blood.
  bladder.
  ureter.
  kidney.
  urethra.

15. The lowest concentration of nitrogenous waste is likely
(1.20) to be found in blood passing through which of the following vessels?

A. Renal vein. **B.** Vena cava. **C.** Hepatic vein.
D. Pulmonary artery. **E.** Renal artery.

16. One of the waste products of protein metabolism is
(1.20)

A. pepsinogen. **B.** trypsin. **C.** amino acid.
D. urea. **E.** urine.

Item 17 deleted.

18. Which of the following structures is not directly asso-
(1.20) ciated with the urinary system in man?

A. Renal capillaries. **B.** Ureter. **C.** Urethra.
D. Renal tubule. **E.** Gall bladder.

19. Which of the following has no relation to excretion?
(1.20)

A. Nephridium. **B.** Nephron. **C.** Hair cell.
D. Flame cell. **E.** All of these.

20. Which of these is the first to break the proper sequence?
(1.20)

A. Kidney. **B.** Urethra. **C.** Bladder.
D. Ureter. **E.** None of these.

21. Which is the first to break the proper sequence?
(1.20)

A. Renal pelvis. **B.** Glomerulus. **C.** Nephron.
D. Collecting tubule. **E.** None of these.

22. The lower concentration of glucose in the blood pass-
(1.20) ing through the renal veins than in blood passing through the renal arteries is explained by the fact that

A. normally some sugar is discharged in the urine.
B. sugar is stored in the renal units.
C. the cells comprising the renal units carry on cellular respiration.

D. sugar, unlike some substances carried by the blood, is soluble in water.
E. the body is an imperfect machine.

23. (1.20) Some substances pass through the capillary membranes of the glomeruli while other substances do not. These capillary membranes are, therefore, considered to be

A. osmotically abnormal.
B. functioning improperly.
C. differentially permeable.
D. more than one of the above.
E. none of the above.

24. (1.20) What happens to most of the water that passes into the filtrate in the kidneys?

A. It is excreted in the urine.
B. It is given off in the form of perspiration.
C. It is utilized in carbohydrate synthesis.
D. It is reabsorbed into the blood.
E. It is converted into digestive fluids which serve as vehicles of transport for enzymes.

25. (1.20) The concentration of which one of the following is not decreased when blood passes through the normal kidneys of a person?

A. Protein. **B.** Glucose. **C.** Urea.
D. Other nitrogenous wastes.
E. All decrease in concentration when passing through the kidneys.

26. (1.20) Which one of the following includes or contains all the others?

A. Renal unit. **B.** Kidney. **C.** Glomerulus.
D. Glomerular capsule. **E.** Renal tubule.

27. (1.20) A marked increase in concentration of which of the following substances occurs in the blood as it flows through a capillary bed in the foot?

A. Glucose. **B.** Oxygen. **C.** Amino acids.
D. Nitrogenous wastes. **E.** None of the above.

28. (1.20) One of the most important functions of the human kidneys is to

A. assist in the elimination of indigestible wastes from the digestive tract.
B. store amino acids.
C. store glycogen for emergency use.
D. excrete nitrogenous substances produced during protein metabolism.
E. eliminate carbon dioxide from the body.

29. (1.20) In the following pair, blacken space 1 if the first element of the pair is definitely greater than the second, space 2 if the second is definitely greater than the first; and space 3 if the two are approximately equal.

A. Number of ureters in a man.
B. Number of ureters in a woman.

30. (1.20) The human urinary system does *not* include the

A. renal unit. **B.** glomerulus. **C.** urethra.
D. Graafian follicle. **E.** ureter.

Items 31 - 39. After each item number on the answer sheet, blacken space

A if the item is true of or associated with flame cells.
B if the item is true of or associated with nephridia.
C if the item is true of or associated with kidneys.
D if the item is true of or associated with more than one of the above.
E if the item is not true of any of the above.

31. (1.20) Function in the elimination of nitrogenous waste products.

32. (1.20) An excretory system in most segments of an earthworm consisting of a coiled tubule and a funnel-like mouth opening into the coelomic cavity.

33. (1.20) An organ made up of a cortex and medulla.

34. (1.20) The tubes draining these organs are called the ureters.

35. (1.20) The excretory system characteristic of plants.

36. (1.20) A system of tubes and cup-shaped cells with a tuft of cilia at the base of the cells.

37. (1.20) The substance of this organ is made up largely of a compact mass of small tubules present in great numbers.

38. (1.20) The elimination of dry, solid wastes is usually associated with the organ.

39. (1.20) The muscular body movements of the animal are responsible for the movement of the coelomic fluid which contains the nitrogenous waste products.

40. (1.20) In a normal healthy man the passage of urea through the sweat glands is

A. equal in quantity to that passed through the kidneys.
B. greater in quantity than that passed through the kidneys.
C. insignificant in quantity compared to that passed through the kidneys.
D. equal in quantity to that amount present in the blood.

41. (1.20) As urine passes through the ureters, bladder, or urethra,

A. no change occurs in the urine.
B urea is reabsorbed.
C. water is absorbed.
D. additional nitrogenous waste products are added.

42. (1.20) The primary function of the sweat glands is to

A. secrete oils which lubricate the skin.
B. regulate the body temperature.
C. discharge urea from the body.
D. secrete the waste products of metabolism.

Items 43 - 56. The following items refer to photosynthesis, respiration, and excretion. After each item number on the answer sheet, blacken space.

A if the item refers to photosynthesis only.
B if the item refers to respiration only.
C if the item refers to excretion only.
D if the item refers to more than one of the above.
E if the item refers to none of the above.

43. (1.20) Oxygen is a by-product and energy is stored.

44. (1.20) Oxygen is used in the process and energy is liberated.

45. The use or production of oxygen is not involved and no (1.20) transfer of energy takes place.

46. Is necessary for the continued existence of animal life. (1.20)

47. Is necessary for the continued existence of plant life. (1.20)

48. Is not necessary for the continued existence of plant or (1.20) animal life.

49. Takes place only in sunlight or other light sources. (1.20)

50. Takes place without the presence of sunlight or other (1.20) light sources.

51. Removes some of the end-products of metabolism. (1.20)

52. Removes the end-product of protein metabolism. (1.20)

53. Is limited to green plants only. (1.20)

54. Is limited to animals only. (1.20)

55. This function occurs in both plants and animals. (1.20)

56. This functions occurs in both non-green plants and (1.20) animals.

57. There is a decrease in concentration of which of the fol- (1.20) lowing in the blood after exercise as compared to the concentration before exercise?

A. Oxygen. **B.** Carbon dioxide. **C.** Lactic acid.
D. Two of these. **E.** All of these.

58. Urinalysis reveals that a certain animal's urine is de- (1.20) cidedly acid in reaction. This animal is most likely a

A. deer. **B.** lion. **C.** horse. **D.** giraffe.
E. goat.

59. Some of the waste products produced by the metabolic (1.20) activities of an ameba are

A. oxygen and nitrogenous wastes.
B. oxygen and carbon dioxide.
C. carbon dioxide and nitrogen.
D. urea and carbon monoxide.
E. nitrogenous products and carbon dioxide.

60. Which one of the following is only indirectly involved (1.20) in the production and excretion of urine?

A. Renal artery. **B.** Hepatic vein. **C.** Glomerulus.
D. Ureter. **E.** Renal tubule.

For items 61 - 64 use the following key to indicate the direction of movement of materials involved between the renal tubule, renal veins, and cells of the kidney.

KEY

A. Blood to tubule. **B.** Tubule to blood.
C. Tubule to cells. **D.** Cells to tubule.
E. Cells to blood.

61. Renal vein has a lower concentration of urea than the (1.20) renal artery because urea moves from the ________.

62. Renal vein has a lower concentration of glucose than (1.20) the renal artery because glucose moves from ________.

63. Renal vein has a higher concentration of blood proteins (1.20) because more water passes from ________ than in the reverse direction.

64. Nitrogen wastes are highly concentrated in urine be- (1.20) cause water passes from ________.

65. It is believed that contractile vacuoles serve mainly to (1.20)

A. discharge nitrogenous wastes. **B.** digest food.
C. transport non-digestible materials to an anal pore.
D. regulate water content.
E. aid respiration, mainly by the discharge of CO_2.

66. Under normal temperature and humidity, increased (1.20) water intake is eliminated from the body chiefly by which of the following?

A. Kidneys. **B.** Skin. **C.** Lungs.
D. Large intestine.

67. Under high temperature and low humidity, increased (1.20) water intake is eliminated from the body chiefly by which of the following organs?

A. Kidneys. **B.** Skin. **C.** Lungs.
D. Large intestine.

68. Which of the following conditions cause an increase (1.20) in urine output?

A. Dry (non-humid) atmosphere.
B. Increased blood pressure.
C. Decreased blood pressure. **D.** Increased exercise.

69. Which of the following organs do not excrete salts? (1.20)

A. Lungs. **B.** Kidneys. **C.** Sweat Glands.
D. None of the above.

70. The organ whose expenditure of energy results in the (1.20) passage of fluid into Bowman's capsule is the

A. glomerulus. **B.** walls of Bowman's capsule.
C. walls of the proximal and distal convoluted kidney tubules.
D. heart. **E.** diaphragm and intercostal muscle.

71. In the kidney, the volume of blood carried per unit of (1.20) time in an arteriole to a glomerulus is

A. greater than the volume in the venule leaving the nephron, and still greater than the volume passing through the vessel leaving the glomerulus.
B. greater than the volume in the vessel leaving the glomerulus, but the same as the volume in the venule leaving the nephron.
C. greater than the volume in the venule leaving the nephron but the same as the volume in the vessel leaving the glomerulus.
D. the same as the volume in both the vessel leaving the glomerulus and the venule leaving the nephron.
E. less than the volume in the vessel leaving the glomerulus but the same as the volume in the venule leaving the nephron.

72. Which of the following conditions cause an increase (1.20) in urine output?

A. Decreased blood pressure. **B.** Dry atmosphere.
C. Increased blood pressure. **D.** Increased exercise.

73. (1.20) In which of the following are the structures listed in order of increasing complexity?

- **A.** Contractile vacuole, flame cell, kidney, nephridium.
- **B.** Contractile vacuole, flame cell, nephridium, kidney.
- **C.** Flame cell, contractile vacuole, nephridium, kidney.
- **D.** Flame cell, contractile vacuole, kidney, nephridium.
- **E.** Nephridium, kidney, flame cell, contractile vacuole.

74. (1.20) The maximum size of molecules, or particles, passing into Bowman's capsule is best indicated, in the healthy man, as at least as large as

- **A.** salt ions, but smaller than glucose.
- **B.** glucose, but smaller than the amino acids.
- **C.** the amino acids, but smaller than proteins.
- **D.** the proteins, but smaller than red blood corpuscles.

75. (1.20) Movement of fluids from arterial blood into the space of Bowman's capsule, in the kidney, is achieved exclusively or mainly by

A. absorption. **B.** diffusion. **C.** filtration.
D. osmosis. **E.** secretion.

Items 76 - 80. Select the correct answer from the key list below for each of the following items.

KEY

A. Malpighian corpuscle. **B.** Ureter. **C.** Urethra.
D. Bladder. **E.** Renal pelvis.

76. (1.20) Which of the above structures is the functional unit of the kidney?

77. (1.20) Which of the above carries urine from the kidney to the bladder?

78. (1.20) Which of the above carries urine from the bladder to the outside of the body?

79. (1.20) Which of the above stores urine and may become markedly distended at times?

80. (1.20) A glomerulus is part of which of the above?

81. (1.20) Generally the amount of water excreted with the urine by mammals is

- **A.** greater than.
- **B.** less than.
- **C.** same as the amount excreted by birds with their urine.

81. (1.20) The liquid which filters through the capillary walls into the cavity of Bowman's capsule is

- **A.** venous blood minus the cells and plasma proteins.
- **B.** urine in concentrated form.
- **C.** used bile to be excreted.
- **D.** whole blood freshly oxygenated.
- **E.** insulin for emergency use.

82. (1.20) Nitrogenous wastes passing through the mammalian body encounter the various excretory structures in the following sequence:

- **A.** cortex, medulla, ureter, bladder, urethra.
- **B.** Bowman's capsule, renal tubule, urethra, bladder, ureter.
- **C.** medulla, urethra, cortex, bladder, ureter.
- **D.** kidney, urethra, bladder, ureter.
- **E.** kidney, bladder, urethra, ureter.

Item 83. After the exercise number on the answer sheet blacken the one lettered space which designates the most similar structure, condition, or process.

83. (2.10) The role of flame cells in a flatworm:

- **A.** The role of red blood corpuscles in man.
- **B.** The role of the mematocysts in the hydra.
- **C.** The role of the nephridia in an earthworm.
- **D.** The role of the pancreas in man.
- **E.** The role of the pseudopodia in an ameba.

Items 84 - 93.

In studying the functions of the kidneys experimentally, certain facts have been discovered. Analysis has shown that the fluid in the capsule has the same percentage composition as blood plasma minus its proteins: It is more dilute than blood plasma and contains sugar and salts. But urine after passing through the tubules, and as it is eliminated from the body, has a greater concentration of nitrogenous waste and contains little or no sugar. The urea excreted by the kidneys is formed mostly in the liver from amino acids which are broken down there and then diffuse into the blood.

After each item number on the answer sheet, blacken space

- **A** if the statement is true on the basis of evidence given above.
- **B** if the statement is true, but not on the basis of evidence given above.
- **C** if the statement is false on the basis of evidence given above.
- **D** if the statement is false, but not on the basis of evidence given above.

84. (2.20) Under normal conditions, sugar, as well as some water, is reabsorbed back into the blood in the tubules of the kidneys.

85. (2.20) Substances from the plasma in the glomerulus pass into the renal capsule by osmosis.

86. (2.20) The volume of blood is maintained by a reduction of urine production when perspiration is profuse.

87. (2.20) The fluid that filters through the capsule into the urinary tubules contains sugar, salts, water, and nitrogenous wastes.

88. (2.20) Only diseases of the kidney and bladder are discovered by examination of urine.

89. (2.20) Infection of the kidney tubules (nephritis) may follow infections elsewhere in the body.

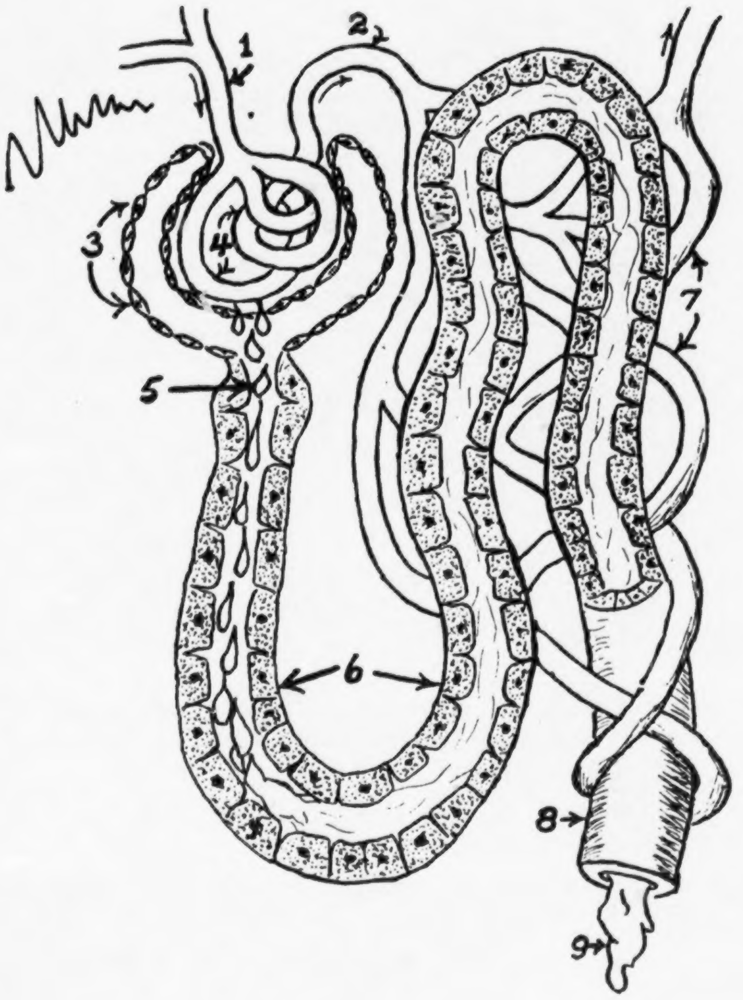
90. (2.20) All substances present in the blood plasma may be detected eventually in the voided urine of a normal individual.

91. (2.20) The cells of the body normally maintain definite concentration of many substances.

92. (2.20) Most of the urea is formed in the kidneys as a result of the metabolism of amino acids.

93. (2.20) Blood pressure in the glomerulus is higher than in capillaries of the body generally.

Items 94 - 101. After each item number on the answer sheet, blacken the one lettered space which designates the number of the given structure in the diagram.



94. (2.20) A urinary tubule of the kidney.

A. 1. **B.** 2. **C.** 3. **D.** 6. **E.** 7.

95. (2.20) A glomerulus.

A. 2. **B.** 3. **C.** 4. **D.** 5. **E.** 6.

96. (2.20) A renal or Bowman's capsule.

A. 3. **B.** 4. **C.** 6. **D.** 7. **E.** 8.

97. (2.20) Materials filter from the blood through the cell membranes of both

A. 1 and 2. **B.** 3 and 4. **C.** 6 and 7. **D.** 8 and 9.

98. (2.20) Glucose, mineral salts, and water are re-absorbed by the blood, as the blood passes through

A. 1. **B.** 4. **C.** 5. **D.** 6. **E.** 7.

99. (2.20) A glomerular arteriole in which blood pressure is highest is indicated by

A. 1. **B.** 2. **C.** 7. **D.** 8.

100. (2.20) Carries urine toward a ureter.

A. 1. **B.** 2. **C.** 7. **D.** 8.

101. (2.20) The liquid labeled 9 normally differs most from that labeled 5 in its much greater concentration of

A. glucose. **B.** urea. **C.** albumin. **D.** water.

102. (2.20) In one of the biological science films the kidneys are likened to an egg-sorting machine. In this illustration what material(s) passing through the kidneys is (are) analogous to the various sized eggs?

A. Urea. **B.** Sodium chloride. **C.** Sugar. **D.** Calcium salts. **E.** All of these.

Items 103 - 106 use the following data as the key.

KEY

Substance	Tissue fluid of a limb (mg./100 cc.)	cell (mg./100 cc.)
A. Carbon dioxide.	60.0	61.0
B. Oxygen.	10.0	9.0
C. Glucose.	50.0	49.0
D. Nitrogen wastes and urea.	38.0	39.0
E. Amino acids.	2.0	1.8

103. (2.20) There is more of this (these) substance(s), which is (are) characteristic of protein metabolism, in the cell than in the tissue fluid.

104. (2.20) There is more of this (these) substance (s), which is (are) characteristic of all kinds of metabolism, in the cell than in the tissue fluid.

105. (2.20) There is more soluble, diffusible carbohydrate in the tissue fluid than in the cell.

1[illegible] (2.[illegible]) This (these) product (s) of protein digestion would diffuse from the tissue fluid to the cell.

107. (2.20) What physiological factor is the most common cause of heat prostration among workmen in such places as deserts, deep mines, boiler rooms, and steel mills?

- **A.** The body experiences greater water loss than can be made up by drinking water.
- **B.** With a constant loss of large amounts of water in the sweat, the salt concentration in the body becomes too high.
- **C.** The osmotic balance in the cells of the body is upset by excessive loss of salt in the sweat.
- **D.** The body loses vital fluids, such as enzymes, in the perspiration, causing a disruption of cell functioning during prolonged periods of excessive perspiring.
- **E.** Low relative humidity prevents the perspiration from evaporating fast enough to cool the body sufficiently.

Items 108 - 117 pertain to the excretory system in man partially illustrated below. For items 108 - 113, which refer to Figure A, mark the answer space corresponding to the number of the structure which fits the item description.

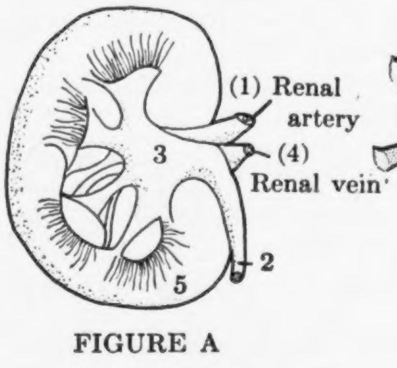


FIGURE A

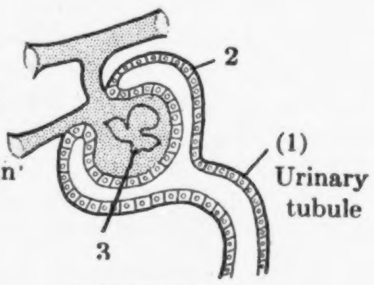


FIGURE B

Items 114 to 117 refer to Figure B above. (Item 113 refers to both A and B).

108. (2.20) The structure which carries purified blood from the kidney toward the heart.

109. (2.20) The kidney structure in which urine is collected from the tubules draining the glomeruli.

110. (2.20) The structure which carries blood, laden with nitrogenous waste, to the kidneys.

111. (2.20) The structure which carries urine to the bladder.

112. (2.20) The cortex of the kidney (secreting region).

113. (2.20) The ureter.

114. (2.20) The material extracted in largest volume by the cells in the urinary tubule is

A. water. **B.** urine. **C.** blood.
D. carbon dioxide. **E.** bile salts.

115. (2.20) Mark the space whose number in *Figure B* indicates the structure which carries urea-laden blood.

116. (2.20) Mark the space whose number in *Figure B* indicates Bowman's Capsule.

117. (2.20) Mark the space number which designates on *Figure A* the region in which the entire structure shown in *Figure B* is located.

118. (3.00) The number of drops of urine excreted per minute from a cut ureter in an anesthetized animal increases sharply if a small amount of *concentrated* glucose solution is injected directly into a vein. This phenomenon tends to demonstrate that

A. glucose is harmful to the body if taken in concentrated form.
B. great increase in bulk of liquid material in the blood stream increases the rate of urine formation.
C. normal urine usually contains glucose in greater or lesser concentration, but the amount increases when the glucose content of the diet or of the blood increases.
D. urine discharge from the kidneys into the ureters is intermittent or periodic rather than continuous.
E. one of the factors responsible for urine separation in the kidneys is osmosis.

119. (3.00) When an individual loses as much as a quart of blood, excretion of urine and perspiration decrease sharply in amount. The occurrence of this phenomenon can best be evaluated by which one of the following?

A. Normal excretory functions will be restored when the high blood pressure is reduced to normal.
B. Protein metabolism and urea formation are temporarily halted.
C. Nerve shock temporarily halts certain body functions.
D. Cellular respiration in the body stops until normal functioning is restored.
E. These are compensatory reactions for maintenance of body water balance.

120. (3.00) A research study of the variation in chemical composition of the sweat of different races could yield the most fruitful objective physiological results for solving which one of the following problems?

A. How do different races compare in their standards of cleanliness?
B. How do various races compare in their susceptibility to heat?
C. Which races are primarily vegetarian with respect to diet?
D. Which races are most lethargic?
E. Which races emit unpleasant body odors.

Items 121 - 127 are based on the data in the table below.

After a period of starvation, which depleted the glycogen from the liver, an animal was fed a meal of pure protein. Analysis of certain constituents of the blood in the hepatic portal vein and hepatic vein was made and recorded in the table below.

Table 1. Analysis of Blood in Vessels Four Hours After Protein Meal

	Concentrations of		
	Amino Acids	Urea	Glucose
Hepatic portal vein (to liver)	8.0 mg. per 100 cc.	30.0 mg. per 100 cc.	80.0 mg. per 100 cc.
Hepatic vein (from liver)	6.0 mg. per 100 cc.	30.7 mg. per 100 cc.	81.0 mg. per 100 cc.

For items 121 - 127 mark space.

A. If the statement is warranted by the evidence.
B. If the statement is contradicted by the evidence.
C. If the statement cannot be judged on the basis of the evidence.

121. (3.00) The liver removes amino acids from the circulatory system.

122. (3.00) Amino acids are synthesized in the liver from urea.

123. (3.00) Urea is either manufactured in or stored in the liver.

124. (3.00) The liver either manufactures or holds in storage a reserve supply of sugar.

125. (3.00) Adrenalin was responsible for the increase in glucose content of the blood from 80 mg. per 100 cc. to 81 mg. per 100 cc.

"Eight milligrams of alanine (an amino acid) containing carbon atoms which were C^{14} and nitrogen atoms which were N^{15} were injected into the hepatic portal vein of an animal. An analysis of the urea taken from a sample of blood from the hepatic vein showed that some of the nitrogen of the urea was N^{15}. An analysis of glucose taken from the hepatic vein showed that some of the glucose molecules contained C^{14} atoms."

On the basis of the above information answer item 126 using the same key as for items 121 - 125.

126. (3.00) Amino acids are catabolized in the liver into urea and glucose.

127. (3.00) "In a diabetic animal there is excretion of glucose in the urine even though the animal is fed a carbohydrate-free diet." This statement tends to support which one of the following hypotheses?

A. The liver discharges amino acids into the circulatory system.
B. Urea is either manufactured or stored in the liver.
C. Amino acids are synthesized in the liver from urea.
D. Amino acids are catabolized in the liver into urea and glucose.
E. None of the above.

128. (3.00) In a mammal, under ordinary circumstances the concentration of urea in the blood leaving a normal kidney is

A. greater than the concentration of urea in the blood in the animal's aorta.

B. less than the concentration of urea in the blood in the animal's aorta.

C. the same as the concentration of urea in the blood in the animal's aorta.

D. sometimes greater than, sometimes less than the concentration of urea in the blood in the animal's aorta.

129. (1.20) The reason for your answer to question 128 is that

A. only part of the venous blood entering the heart comes directly from the kidney, and urea leaves the blood only in the kidney.

B. all blood is "purified" in one complete circuit.

C. blood from the kidneys passes through all the body posterior to the diaphragm before returning to the heart.

D. the blood leaving the kidneys passes into the hepatic portal vein and traverses the liver before reaching the heart.

E. the quantity of urine formed is dependent upon the amounts of water entering and leaving the blood in other parts of the body.

17. Nervous System—Structure and Function

NERVOUS SYSTEM — STRUCTURE AND FUNCTION

1. (1.10) Stimuli superimposed upon other stimuli tend to develop that type of nervous connection known as

A. axons. **B.** ganglia. **C.** plexi.
D. conditioned reflexes. **E.** instincts.

2. (1.10) A dendrite is part of

A. a bone cell. **B.** a nerve cell.
C. a striated muscle cell. **D.** an epithelial cell.
E. a connective tissue cell.

3. (1.10) The many small branches of a nerve cell are called

A. ganglia. **B.** dendrites. **C.** flagella.
D. synapses. **E.** neurones.

4. (1.10) Accommodation of the lens of the eye for seeing near or distant objects would be classified as

A. a tropism. **B.** a habit.
C. a conditioned reflex. **D.** a simple reflex.
E. an act of volition.

5. (1.10) New associations of stimuli and responses as they are learned form nervous connections known as

A. reflex arcs. **B.** conditioned reflexes.
C. instincts. **D.** synapses. **E.** dendrites.

6. (1.10) The autonomic nervous system

A. carries nerve impulses to and from the arms and legs.
B. is the line of communication between the special sense organs and the brain.
C. constitutes the nervous mechanism for coordinating the maintenance systems and other vital functions.

7. (1.10) An individual nerve cell:

A. axon. **B.** dendrite. **C.** neuron.
D. neurilemma. **E.** myelin sheath.

8. (1.10) An invariable response toward or away from a stimlus:

A. habit. **B.** tropism. **C.** reflex. **D.** instinct.
E. synapse.

9. (1.10) A group of nerve cell bodies and their connections:

A. synapse. **B.** plasmodesmata. **C.** choroid.
D. dendrone. **E.** ganglion.

10. (1.10) A nervous system composed of cranial and spinal nerves:

A. peripheral. **B.** autonomic. **C.** central.
D. branchial. **E.** gray matter.

11. (1.10) A secretion from a nerve ending:

A. thyroxin. **B.** insulin. **C.** sympathin.
D. secretin. **E.** adrenalin.

12. (1.10) Sensitivity or irritability is found only in

A. animals. **B.** plants.
C. animals with a nervous system. **D.** sense organs.
E. living protoplasm.

13. (1.10) The so-called seat of consciousness in man is located most precisely in

A. the cerebellum. **B.** the cerebrum.
C. the spinal cord. **D.** the medulla.
E. none of the above.

14. (1.10) The part of the brain directly associated with the learning process is the

A. cerebellum. **B.** pons. **C.** cerebrum.
D. midbrain. **E.** medulla.

15. (1.10) A gland that secretes hormones

A. salivary. **B.** exocrine. **C.** stomach.
D. mucous. **E.** endocrine.

16. (1.10) The essential organ of hearing

A. malpighian layer. **B.** eustachian tube.
C. ossicles. **D.** organ of corti.
E. cells of helmholtz.

True - False.

17. (1.10) The chorion is the heavily pigmented coat of the eye between the sclera and the retina.

True - False.

18. (1.10) The respiratory center of higher animals is located in the medulla of the brain.

True - False.

19. (1.10) An automatic reaction in animals involving lower nerve centers is known as a reflex.

20. (1.10) The light-refracting body immediately behind the iris of the eye:

A. cornea. **B.** conjunctiva. **C.** lens.
D. sclera. **E.** pupil.

21. (1.10) Which of the following structures are afferent?

A. Arteries. **B.** Motor neurons. **C.** Axones.
D. Sensory neurons. **E.** None of these.

22. (1.10) Irritability is characteristic of

A. mammals only. **B.** mankind only.
C. vertebrates only. **D.** all animals but not plants.
E. all living things.

23. (1.10) The term irritability when used in a biological sense refers to

A. the ability to respond to stimuli.
B. the ability to move.
C. mental processes associated with speech.
D. the ability to register dissatisfaction.
E. none of the above.

24. (1.10) When a barefooted person steps on a sharp object with his right foot, the left leg becomes rigid as the right foot is suddenly withdrawn. This type of compensation prevents the individual from also sitting on the sharp object and occurs because of a nerve phenomenon known as

A. conditioned reflex. **B.** chromatic aberration.
C. refractory period. **D.** cross-extension.
E. inhibition.

25. (1.10) Studies show that a certain cell conducts impulses but performs no other function well. Such a cell would best be classified as

A. a muscle cell. **B.** a gland cell.
C. an epithelial cell. **D.** a cartilage cell.
E. a nerve cell.

26. (1.10) Which one of the following terms is applied to the gap between the dendrite of one neuron and the end-brush of the next neuron?

A. Syndrome. **B.** Syzygy. **C.** Synapse.
D. Synesis. **E.** Synergid.

27. (1.10) Smooth muscles are innervated by

A. the autonomic nervous system.
B. the central nervous system.
C. the peripheral nervous system.
D. all of the above. **E.** none of the above.

28. (1.10) The ganglia are

A. parts of the lymphatic system in which white corpuscles destroy bacteria.
B. segments of the abdomen of the grasshopper.
C. bead-like groups of cells found at intervals along the epididymis.
D. groups of secreting cells found as islands on the pancreas.
E. groups of nerve cell bodies.

Items 29 - 33. Each of items 29 - 33, structures of the eye, corresponds to one of the following brief descriptive terms:

A. delicate transparent membrane in front of eye and lining eyelids.
B. inner coat containing rods and cones.
C. tough outer coat.
D. transparent outer coat in front of eye.
E. vascular middle coat.

29. (1.10) Choroid. **30.** (1.10) Conjunctiva. **31.** (1.10) Cornea.

32. (1.10) Retina. **33.** (1.10) Sclerotic.

34. (1.10) The part of the brain directly associated with the learning process is the

A. cerebellum. **B.** pons. **C.** cerebrum.
D. midbrain. **E.** medulla.

35. (1.10) The shortest pathway over which impulses can travel from a stimulated sense organ to an effector is called

A. a nerve. **B.** a conditioned reflex. **C.** a neuron.
D. a reflex arc. **E.** a synapse.

36. (1.10) The direction of impulse conduction between neurons is believed to be established at the

A. axons. **B.** receptors. **C.** cell body.
D. dendrites. **E.** synapses.

37. (1.10) New associations of stimuli and responses as they are learned form nervous connections known as

A. reflex arcs. **B.** conditioned reflexes.
C. instincts. **D.** synapses. **E.** dendrites.

38. (1.10) Which of the following constitutes the main defense mechanism of Hydra?

A. Trichocysts. **B.** Statocysts. **C.** Nematocysts.
D. Injection tubule.

Items 39 - 43. Which of these parts perform the following functions in Paramecium?

A. anal spot. **B.** body surface.
C. contractile vacuole. **D.** mouth
E. neuromotor system

39. (1.10) Coordination. **40.** (1.10) Egestion.

41. (1.10) Ingestion. **42.** (1.10) Osmotic control.

43. (1.10) Respiration.

44. (1.10) The nuclei of the cells which conduct the impulses in a nerve are located in

A. the periphery of the nerve.
B. the sheath surrounding each fiber.
C. ganglia or in the brain or spinal cord.
D. the centers of the fibers.
E. the organs innervated by the nerve.

45. (1.10) Impulses are thought to be transmitted across synapses in the autonomic (visceral) nervous system by

A. inorganic ions. **B.** electrons.
C. organic compounds.
D. the continuity of protoplasm.
E. mechanisms as yet unknown.

46. (1.10) A spinal nerve is

A. a portion of a single cell.
B. composed of sensory fibers.
C. composed of motor fibers.
D. composed of many whole neurons.
E. composed of portions of many neurons.

47. (1.10) A nerve fiber is

A. a composite formed of several cells.
B. an entire cell. **C.** a part of a cell.

48. (1.10) The physiological union between two nerve cells is spoken of as

A. an axon. **B.** a dendrite.
C. a cellular dissepiment. **D.** a synapse.
E. a neuron.

49. (1.10) The autonomic nervous system

A. innervates the smooth muscles.
B. under ordinary circumstances does not act except in emotion.
C. has no connection with the central nervous system.
D. is primarily a sensory system.

50. (1.10) Concerning the following, which is not a part of a neuron?

A. Dendrite. **B.** Effector. **C.** End brush.
D. Cytoplasm. **E.** Nucleus.

51. (1.20) The nervous system in man regulates

A. the amount of calcium in the blood.
B. the stimulation and inhibition of growth processes.

C. the oxidation of carbohydrates.
D. body adjustment to the external environment.
E. certain physiological processes, such as the uterine-wall recovery following menstruation.

52. (1.20) The function of the ciliary body of the eye is

A. to distinguish between light and dark objects.
B. to distinguish different colors.
C. to regulate the amount of light entering the eye.
D. to focus the lens.
E. to eliminate peripheral light rays thus insuring a sharp image when seeing nearby objects.

53. (1.20) Which of the following would not be classified as a purely automatic response?

A. Breathing. B. Digestion. C. Walking.
D. Knee jerk. E. Maintenance of equilibrium.

54. (1.20) The aperture of the pupil of the eye is increased by the action of

A. sphincter muscle. B. radial muscles.
C. oculo-motor muscles. D. hormones. E. cilia.

55. (1.20) The principal function of the rods of the retina is to

A. enable us to distinguish colors.
B. make possible achromatic or colorless vision.
C. enable us to see an object from more than one vantage point.
D. enable us to get a perception of depth.
E. accommodate for distant and close-up vision.

56. (1.20) It is correct to state that

A. the production of heat does not accompany transmission of nerve impulses.
B. nerve impulses do not follow the same laws as do electrical transmissions.
C. the strength of a nerve impulse depends upon the strength of the stimulus applied to the nerve fiber.
D. immediately after transmitting an impulse, a nerve fiber can transmit another stimulus.
E. the impulses traveling in the optic nerves are physically different from the impulses traveling in the auditory nerves.

Items 57 - 66. On the blank before each response write the letter, selected from the list, for the type of stimulus involved.

Types of Stimuli

A. Chemical. B. Tactile. C. Photic.
D. Thermal. E. Osmotic.

57. (1.20) ______stimulation of cold spots on the back of the hand.

58. (1.20) ______sensation of colors by cones in retina.

59. (1.20) ______pain in a stomach ulcer caused by the gastric juice.

60. (1.20) ______seasickness or sensations of nausea from riding rapidly in an elevator.

61. (1.20) ______stimulation of nasal nerve endings by an aromatic substance.

62. (1.20) ______sensation of black and white by rods in the retina.

63. (1.20) ______sensation of pain from a pin prick.

64. (1.20) ______sweet taste of honey at tip of tongue.

65. (1.20) ______local nerve block administered by a dentist prior to extracting a tooth.

66. (1.20) ______"closing" of leaves of clover, oxalis, and locust at night.

67. (1.20) The nature of the nerve impulses which cause the salivary glands to secrete is basically

A. like the impulses causing muscle contraction.
B. like an electrical current. C. a chemical reaction.
D. different from the impulses causing a slower heart rate.
E. different from the impulses causing intestinal contraction.

68. (1.20) A person born with only the inner ear missing

A. would be missing the Eustachian tube.
B. could never be able to hear sound.
C. could hear an explosion.
D. could hear only with an electronic hearing aid.
E. might have the three earbones malformed.

69. (1.20) Which of the following is an effector?

A. Mind. B. Nerve cell. C. Muscle.
D. Sense organ. E. Bone.

70. (1.20) The conditioned reflex differs from the unconditioned reflex in that the nerve impulse travels over a different

A. sensory neuron only. B. connecting neuron only.
C. motor neuron only.
D. sensory and connecting neuron.
E. sensory and motor neuron.

71. (1.20) A motor neuron carries impulses from the

A. receptor to the effector.
B. effector to the receptor.
C. receptor to the spinal cord.
D. spinal cord to the effector.
E. sense organ to the connecting neuron.

72. (1.20) Which of the following is the first to break the proper sequence?

A. Receptor. B. Sensory neuron.
C. Motor neuron. D. Synapse. E. Effector.

73. (1.20) All *except* which one of the following body activities are controlled by the cerebrum?

A. Circulation of the blood.
B. Perception of moving objects in subdued light.
C. Making a decision.
D. Learning scientific names and associating them with particular organisms.
E. Manipulation of the fingers as when tying a necktie.

74. (1.20) All except which one of the following are components of normal vision in man?

A. Sensitivity to light. B. Form perception.
C. Mosaic image formation. D. Color perception.
E. Depth and distance perception.

75. (1.20) In the following pair, blacken space 1 if the first element of the pair is definitely greater than the second; space 2 if the second is definitely greater than the first; and space 3 if the two are approximately equal.

A. Neurons involved in a simple reflex reaction.
B. Neurons involved in a simple thought reaction.

76. (1.20) In the following pair, blacken space 1 if the first element of the pair is definitely greater than the second; space 2 if the second is definitely greater than the first; and space 3 if the two are approximately equal.

A. Rate of respiration before painful stimulation of the leg.
B. Rate of respiration immediately after painful stimulation of the leg.

Items 77 - 80. For each question, blacken the appropriate letter or letters chosen from the key list.

KEY

A. Brain. **B.** Sensory nerve. **C.** Motor nerve.
D. Spinal cord. **E.** Vagus.

77. (1.20) The center for visual sensations.

78. (1.20) Nerve to eye muscle.

79. (1.20) Directly affects the heart rate.

80. (1.20) Nerve from ear.

81. (1.20) When an adult person has his eyes examined it is sometimes necessary for the oculist to dilate the pupils. This is accomplished by

A. anaesthetizing the optic nerve.
B. temporarily paralyzing the muscles in the iris.
C. having the patient wear bifocal lenses for a few days.
D. accommodating the retina.
E. making a corneal transplant.

82. (1.20) The sciatic nerve in a frog's thigh is severed. When the cut end of the nerve leading toward the toes is stimulated by pricking it with a sharp pointed needle the muscles in the foot respond. This response is

A. a reflex action. **B.** a conditioned reflex.
C. a voluntary action. **D.** an intuitive action.
E. none of the above.

83. (1.20) When the ventral root of the right sciatic nerve in a decerebrated frog is cut, which of the following results can be expected?

A. The frog will be unable to move its right leg.
B. The frog will be unable to move either leg.
C. Sensory impulses will be unable to travel from the right foot to the spinal cord.
D. All the neurons in the right leg will become permanently non-functional.
E. All of the above are likely to result.

84. (1.20) When the dorsal root of the left sciatic nerve in a decerebrated frog is cut, which one of the following results can be expected to follow?

A. The frog will be unable to move its left leg.
B. No sensory impulses can be transmitted from the left leg to the spinal cord.
C. The synapses in the reflex arcs involving the left leg are destroyed.
D. The right leg becomes immobilized.
E. None of the above is likely to result.

85. (1.20) If the ventral root of a spinal nerve should be cut, the result in the tissue or region which that nerve supplies would be

A. complete loss of sensation.
B. complete loss of motor action.
C. complete loss of both sensation and motor action.
D. complete loss of sensation, motor action, and autonomic control of blood vessels, etc.
E. loss of neither sensation nor motor action, but only of autonomic control of blood vessels, etc.

Item 86 deleted.

87. (1.20) Sensation of cold would be received by nerve endings of the

A. sympathetic nervous system.
B. cranio-sacral nervous system.
C. central nervous system.
D. peripheral nervous system.
E. thoraco-lumbar nervous system.

88. (1.20) Which one of the following activities in man would not be classified as a purely automatic response?

A. Respiration. **B.** Circulation of the blood.
C. The knee jerk when the patella is struck.
D. Maintaining equilibrium.
E. Maintaining good hygienic posture.

89. (1.20) Possession of both a nervous system and an endocrine system

A. is typical of all living organisms.
B. is characteristic of all animals but of no plants.
C. distinguishes the higher animals from the lower animals and plants.
D. would be a hazard and a liability to any organism possessing them.
E. distinguishes man from all other living organisms and is in large measure responsible for man's superiority among the living things on the earth.

90. (1.20) The nervous system in man

A. controls the oxidation of carbohydrates.
B. functions in the stimulation and inhibition of the growth processes.
C. regulates body adjustment to the external environment.
D. stimulates glycogen release into the blood during fright.
E. controls the amount of calcium present in the blood at all times.

91. (1.20) The first part of a neuron encountered by a nerve impulse is the

A. myelin sheath. **B.** cell body. **C.** dendrite.
D. axon. **E.** end brush.

92. (1.20) Which of the following characterizes the peripheral nervous system?

A. It consists of the nerves which connect the brain and spinal cord to the internal organs of the body, such as the heart, the stomach, and the intestines.
B. It consists of the brain and spinal cord.
C. It consists of the nerves which extend from the brain and spinal cord to muscles and glands near the surface of the body and in the body extremities.
D. It consists of a cell body, a nucleus, one or more dendrites, an axon and an end brush.
E. It consists of a sensory neuron, a synapse, and a motor neuron.

93. (1.20) All except which one of the following are included in the central nervous system?

A. Cerebrum. **B.** Cerebellum.
C. Medulla oblongata. **D.** Spinal cord.
E. Autonomic trunk.

94. (1.20) All except which one of the following are parts of a neuron?

A. Cytoplasm. **B.** Nucleus. **C.** End brush.
D. Dendrite. **E.** Effector.

95. (1.20) Which of the following statements about muscle tonus is most nearly correct?

A. It is destroyed completely by fatigue.
B. It is usually increased by fatigue.
C. It is usually decreased by fatigue.
D. It is usually unaffected by fatigue.
E. It has no relationship to fatigue.

96. (1.20) The reason a nerve impulse normally travels in one direction only from dendrite to axon within a neuron is because of a directing mechanism in the

A. axon. **B.** dendrite. **C.** cell body.
D. synapse. **E.** connection with the effector.

97. (1.20) The principal function of the rods of the retina is to

A. make possible colorless vision in dim light.
B. enable us to distinguish colors.
C. enable us to get a perception of depth.
D. accommodate for distant and close-up vision.
E. hold the retina in place against the inner surface of the eyeball.

98. (1.20) Of the following paths the one followed by a nerve impulse along a simple reflex arc is

A. receptor, axon, cell body, dendrite, synapse, axon, cell body, dendrite, effector.
B. effector, axon, cell body, dendrite, synapse, axon, cell body, dendrite receptor.
C. receptor, dendrite, cell body, axon, synapse, dendrite, cell body, axon, effector.
D. effector, axon, cell body, dendrite, synapse, axon, cell body, dendrite, receptor.
E. receptor, dendrite, cell body, axon, synapse, axon, cell body, dendrite, effector.

99. (1.20) Intelligence in the human being is thought to be

A. a result of inheritance alone, environment playing no part.
B. a result of environment alone, heredity playing no part.
C. a result primarily of heredity, although environmental influences may act within limits set by heredity.
D. a result primarily of environment, although heredity may influence development to a certain extent.
E. dependent primarily upon only one factor, namely education, heredity playing a part, but only a small part.

100. (1.20) Writing a paragraph on a typewriter without concentration on the actual mechanics of typing is an example of

A. a conditioned reflex. **B.** a simple reflex.
C. a thought action.
D. an acquired automatic action. **E.** an instinct.

101. (1.20) A frog may have a certain major part of the nervous system removed with no great accompanying change in behavior. That part is

A. the spinal cord. **B.** the cerebrum.
C. the medulla. **D.** a sympathetic trunk.
E. the upper third of the spinal cord.

102. (1.20) The function of the eustachian tubes is

A. to equalize air pressure on both sides of the ear drum.
B. to help us maintain our equilibrium.
C. to equalize blood pressure in all parts of the body during exercise.
D. to determine basal metabolic rate.
E. to resonate the sounds produced by the vocal cords.

103. (1.20) Which one of the following is not a part of a simple reflex arc?

A. Sensory neuron. **B.** Synapse. **C.** Cerebrum.
D. Dendrite. **E.** Motor neuron.

104. (1.20) Astigmatism is a condition in which

A. the muscles regulating the movement of the eyeball function imperfectly.
B. the eyes are subject to frequent, recurrent infection.
C. the image of the object seen comes to a focus in front of the retina.
D. the corneal curvature is imperfect.
E. there is a deficiency of visual purple in the retina.

105. (1.20) With the result that

A. the person cannot see in dim light.
B. the object seen appears blurred.
C. the individual cannot see distant objects.
D. total or partial blindness is inevitable.
E. one eye does all the seeing while the other remains idle.

106. (1.20) The autonomic nervous system functions chiefly in

A. the coordination of muscular activities such as those used by a basketball player in shooting a basket.
B. the reception of sensory stimuli.
C. the innervation of smooth muscles in the viscera.
D. the solution of complex problem situations which involves the application of many previously learned rules.
E. emotionally upsetting types of situations.

107. In listing the component structures of a reflex arc in the
(1.20) order of their activation, the structure in the following list which is out of correct sequence is

A. receptor. **B.** afferent nerve. **C.** synapse.
D. efferent nerve. **E.** sensory neuron.

108. Many living organisms are characterized by a form of
(1.20) self-regulation designated as compensatory reactions. Which one of the following compensatory reactions would be *least* likely to take place in man?

A. If one kidney is destroyed by disease the other kidney does the work of two.
B. Increased physical exertion over a long period of time may result in a definite enlargement of the heart.
C. An inadequate secretion of thyroxin may result in enlargement of the thyroid gland.
D. Injection of foreign protein or bacterial poisons into the blood may result in the production of antibodies.
E. Destruction of the cerebrum may result in its functions being taken over by the cerebellum.

109. All except which one of the following are components
(1.20) of normal vision in man?

A. Sensitivity to light. **B.** Form perception.
C. Mosaic image formation. **D.** Color perception.
E. Depth and distance perception.

Items 110 - 115. The output of the heart is controlled by certain nerves. These may be stimulated, cut, etc. Outputs may be

A. greater after the treatment.
B. less after the treatment.
C. same after the treatment.

What would be the effects of the following?

110. Cut the vagus. **111.** Stimulate the vagus.
(1.20) **(1.20)**

112. Stimulate the depressor.
(1.20)

113. Stimulate the depressor in an animal in which the vagus
(1.20) has been cut some time previously.

114. Stimulate the accelerator.
(1.20)

115. Stimulate the accelerator in an animal in which the
(1.20) vagus has been cut some time previously.

116. The cerebellum of an experimental animal is injured.
(1.20)

A. Regulation and maintenance of respiration and circulation are impaired.
B. The amount of fatty tissue in the body will increase.
C. Muscular coordination and the control of equilibrium are affected.
D. Marked restlessness, morbid hunger, and mental deficiency occur.
E. The regulation of the sleeping-waking rhythm is affected.

117. Impulses are transmitted by intercostal nerves.
(1.20)

A. The heart rate is decreased.
B. The heart rate is increased.
C. The muscles of the diaphragm contract.
D. Air rushes into the lungs.
E. The sensation of hunger occurs in the brain.

118. The phrenic nerves are severed.
(1.20)

A. The heart rate is increased.
B. The heart rate is decreased.
C. The rhythmic contraction of the diaphragm stops at once.
D. The intercostal muscles will no longer function.
E. The dilation of the arterioles is decreased.

119. Auditory sensations are carried to the brain from nerve-
(1.20) endings in the

A. cochlea. **B.** semicircular canals. **C.** eardrum.
D. earbones. **E.** ear canal.

120. The rate of transmission of a nerve impulse
(1.20)

A. increases with increase in the strength of the stimulus.
B. varies with the kind of stimulus.
C. is constant.
D. depends on the number of previous stimuli.
E. is constant no matter what the strength of the stimulus.

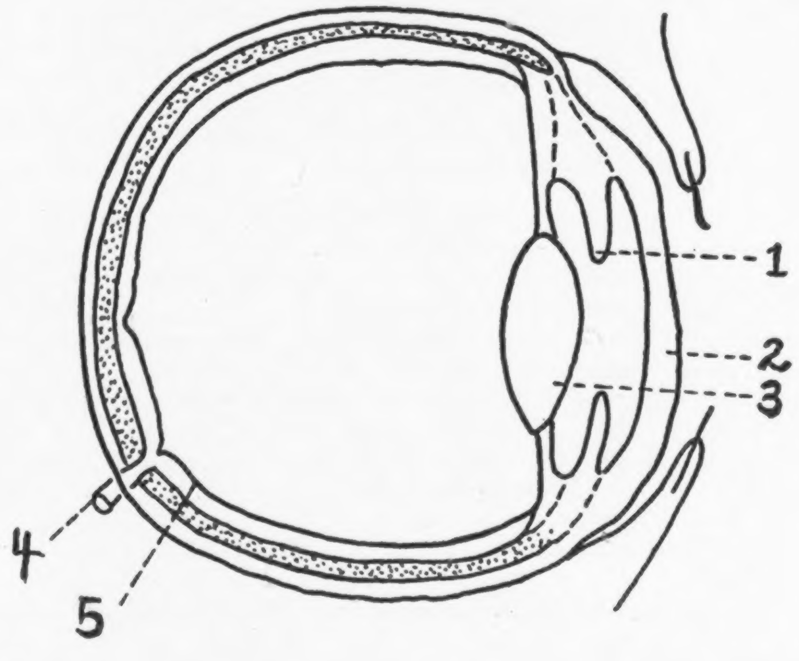
121. The medulla is that part of the brain which has centers
(1.20) for

A. chemical control of sexual development and skeletal growth.
B. fat metabolism, temperature regulation, and water balance.
C. control of breathing, heart beat, and blood vessel diameter.
D. control of voluntary muscular movements, and perception of skin sensations.
E. hearing, vision, taste, and smell.

122. Damage to the cerebellum may result in
(1.20)

A. paralysis of all voluntary muscles.
B. loss of sensation from all parts of the skin.
C. loss of hearing.
D. paralysis of only the voluntary muscles of the limbs.
E. impaired coordination of voluntary muscular movement.

Questions 123 thru 126 are based on the diagram of a typical vertebrate eye, on which certain structures are numbered. Identify the structures listed in the questions with those numbered on the diagram.



123. Cornea. **124.** Retina.
(1.20) (1.20)

125. Structure which functions in focusing the light rays.
(1.20)

126. Structure which functions in carrying the visual stimuli
(1.20) to the brain.

127. Snake venoms consist partly of neurotoxins which affect
(1.20) various nerve centers. One of the symptoms of snakebite poisoning is low blood pressure. This is probably due to some derangement of the

- **A.** motor area of the cerebral cortex.
- **B.** skin sensory area of the cerebral cortex.
- **C.** respiratory center in the medulla oblongata.
- **D.** center for muscular coordination in the cerebellum.
- **E.** vasomotor center in the medulla oblongata.

128. Destruction of the motor areas of the right cerebral
(1.20) cortex results in loss of

- **A.** sensation from the right side of the body.
- **B.** sensation from left side of the body.
- **C.** voluntary muscular movements of the right side of the body.
- **D.** voluntary muscular movements of the left side of the body.
- **E.** coordinated muscular movements of the left side of the body.

129. The sequence of structures involved in a simple reflex
(1.20) arc is

- **A.** axon, cell body, dendrite, gray matter, synapse.
- **B.** receptor, afferent neuron, synapse, efferent neuron, effector.
- **C.** receptor, efferent neuron, synapse, afferent neuron, effector.
- **D.** effector, afferent neuron, synapse, efferent neuron, receptor.
- **E.** receptor, afferent neuron, synapse, adjustor.

130. Cutting across the afferent (sensory) fibers of the nerves
(1.20) of the hind limbs

- **A.** prevents voluntary contraction of muscles of the hind limb.
- **B.** has no effect on sensation or voluntary contraction of the muscles of the limbs.
- **C.** results in temporary loss of voluntary contraction of the hind limb.
- **D.** results in loss of feeling in the hind limbs.
- **E.** results in loss of sensation and voluntary contraction of muscles of the hind limbs.

After the exercise number on the answer sheet blacken the one lettered space which designates the most similar structure, condition, or process.

131. The appearance of the dendrites of a neuron:
(1.20)

- **A.** The cilia of a paramecium.
- **B.** The pseudopodia of an ameba.
- **C.** The flagellum of a sperm cell.
- **D.** The nucleus of an ordinary cell.
- **E.** The branches of a tree.

132. Which one of the following effectors is self-activating?
(1.20)

- **A.** A salivary gland. **B.** The heart.
- **C.** The biceps muscle in the upper arm.
- **D.** An adrenal gland. **E.** The liver.

133. Which one of the following is true of the cranial nerves
(1.20) that lead to the heart?

- **A.** They initiate the heart beat.
- **B.** They are entirely sensory in function.
- **C.** They are peripheral nerves.
- **D.** They carry impulses which control the rate of the heart beat.
- **E.** None of the above is true.

134. Which one of the following belongs to the central ner-
(1.20) vous system?

- **A.** A rod or a cone in the retina of the eye.
- **B.** A connecting neuron in the spinal cord.
- **C.** The nerve ending in a taste bud.
- **D.** A cold spot on the back of the hand.
- **E.** A terminus of the olfactory nerve in the nasal membrane.

135. Which of the following is the major function of re-
(1.20) ceptors?

- **A.** They control the automatic functions of the body.
- **B.** They produce responses after stimuli have been received.
- **C.** Their major function is to coordinate stimulus and response.
- **D.** They give organisms sensitivity to their environment.
- **E.** Their function is unknown.

136. Perception by means of sight is not affected noticeably
(1.20) by which one of the following?

- **A.** Color of object.
- **B.** Color of the iris of a normal pigmented individual.
- **C.** Intensity of light.
- **D.** Duration of stimulus on retina.
- **E.** Distance of object from observer.

137. In which one of the following would the nerve impulses
(1.20) probably traverse the smallest number of synapses?

- **A.** Sneezing after sniffing some irritating substance.
- **B.** Maintaining an upright position while walking up an icy hill.
- **C.** Solving a mathematics problem.
- **D.** Batting a pitched ball into an area where there are no fielders.
- **E.** Reading a line of poetry.

138. Which one of the following advantages favor the use
(1.20) of frog muscles over cat muscles in experiments involving contraction of excised muscles?

- **A.** Frog muscles are smaller.
- **B.** The cells of cat muscles are more complex.
- **C.** The frog is a cold blooded animal.
- **D.** Cat muscle would have to be kept moist in order to continue functioning.
- **E.** Cat muscle would have to be stimulated before it would contract.

139. A reflex may become a conditioned reflex if it
(1.20)

- **A.** involves the original stimulus but no new stimulus.
- **B.** involves a new response.
- **C.** involves a new association of stimulus and response.
- **D.** involves the peripheral nervous system only.
- **E.** involves something other than the above.

140. Which of the following is least significant in determin-
(1.20) ing length of reaction time?

- **A.** Number of nerve cells involved.
- **B.** Distance impulse travels.

C. Response of muscle to impulse.
D. Magnitude of impulse.
E. Whether response is voluntary or reflex.

141. The energy of sound waves first becomes translated into
(1.20) nerve impulse in the

A. typanum. **B.** ampullae. **C.** pinnae.
D. semicircular canals. **E.** cochlea.

142. Light energy is first translated into nerve impulse in
(1.20) the

A. anterior chamber. **B.** vitreous humor.
C. retina. **D.** lens. **E.** ciliary body.

143. The principal reason why it is better that we have two
(1.20) eyes than one is that

A. we are thereby enabled to see in the dark and in very dim light.
B. by having two eyes we can distinguish colors.
C. this enhances depth perception.
D. this makes accommodation possible.
E. this gives man a type of vision known as mosaic vision.

144. An environmental stimulus first acts upon
(1.20)

A. receptors. **B.** effectors. **C.** connecting neurons.
D. motor neurons. **E.** none of the above.

145. The central nervous system consists of
(1.20)

A. the brain only. **B.** a neuron.
C. the brain and spinal cord.
D. receptors, neurons, and effectors.
E. the brain and autonomic chain.

146. A motor neuron carries impulses from the
(1.20)

A. receptor toward the effector.
B. effector toward the receptor.
C. receptor toward the spinal cord.
D. spinal cord toward the effector.
E. sense organ toward the connecting neuron.

147. If ability to play the piano makes for greater initial
(1.20) progress in learning to operate a typewriter, this is an example of

A. conditioned response. **B.** overlearning.
C. residual learning. **D.** extinction of conditioning.
E. transfer of learning.

148. The number of impulses which are transferred from
(1.20) the axon of one neuron over the synapse to the dendrite of another neuron is

A. greater than. **B.** less than.
C. same as the number which are transferred over the synapse in the opposite direction.

149. Degree of nervous control of salivary secretion is
(1.20)

A. greater than. **B.** less than.
C. same as the degree of nervous control of pancreatic secretion.

150. A conditioned reflex differs from a simple reflex in
(1.20) that it

A. is more rapid.
B. involves different effectors.
C. involves substitution of a stimulus.
D. is inborn. **E.** is the response to a buzzer.

151. Responding when your name is called is
(1.20)

A. a simple reflex. **B.** a learned response.
C. instinctive behavior. **D.** all of the above.
E. none of the above.

152. The knee jerk in response to a sharp blow just below
(1.20) the knee cap is an example of

A. voluntary response. **B.** instinctive behavior.
C. intuitive behavior. **D.** conditioned reflex.
E. simple reflex.

153. A frog from which only the cerebrum has been re-
(1.20) moved would likely be incapable of performing which one of the following?

A. Breathing. **B.** Jumping when pricked with a pin.
C. Withdrawing its leg if an electric shock is applied to the foot.
D. Responding to a loud noise.
E. Swallowing small pieces of food placed at the pharyngeal opening into the esophagus.

154. Which one of the following is not a necessary struc-
(1.20) ture in accomplishing most reflex actions?

A. Sensory nerve. **B.** Effector.
C. At least one synapse. **D.** Cerebrum.
E. Spinal cord.

155. Four of the following are external receptors. Which one
(1.20) would be classified in the category of internal receptors?

A. Semi-circular canals of the ear. **B.** Taste buds.
C. Olfactory nerve-ending in the nose.
D. Pain spots in the palm of the hand. **E.** The eyes.

156. Man is superior to all other animals in which of the
(1.20) following?

A. Keenness of sense of smell.
B. Keenness of sense of sight. **C.** Fleetness on foot.
D. Ability to use substitutes for direct experience.
E. None of the above.

157. Which of the following is an example of a conditioned
(1.20) reflex?

A. The knee jerk as it occurs when a sharp blow is struck just below the knee cap of the crossed leg.
B. The building of a cell in a honey comb by a bee.
C. Watering of the mouth when one smells newly baked bread.
D. The crying of an infant when it experiences the feeling of being dropped.
E. The digestion of food as it passes through the digestive tract.

158. Four of the following are essential to a reflex arc.
(1.20) Which one is not?

A. Sensory neuron. **B.** Motor neuron.
C. Synapse. **D.** Cerebrum. **E.** Spinal cord.

159. With respect to the manner of passage of a nerve
(1.20) impulse along a nerve fiber, the nerve fiber can be likened to

A. a fuse leading to an explosive.
B. a water pipe carrying water.
C. an electrical insulator.
D. a conveyor belt for carrying isolated articles.
E. a relay station which strengthens electrical signals.

160. (1.20) All except which one of the following would be regarded as automatic reflexes?

- **A.** Migration of eels to the Sargasso Sea for mating.
- **B.** A big-league pitcher placing his pitch so its cuts the inside corner of the plate.
- **C.** A pair of orioles building their first typical oriole nest in a new environment.
- **D.** An infant crying at the sound of a loud clap of thunder.
- **E.** An infant suckling at the breast for the first time.

161. (1.20) Which of the following is least significant in determining length of reaction time?

- **A.** Number of nerve cells involved.
- **B.** Distance impulse travels.
- **C.** Response of muscle to impulse.
- **D.** Magnitude of impulse.
- **E.** Whether response is voluntary or reflex.

162. (1.20) A reflex may become a conditioned reflex if it

- **A.** involves the original stimulus but no new stimulus.
- **B.** involves a new response.
- **C.** involves a new association of stimulus and response.
- **D.** involves the peripheral nervous system only.
- **E.** involves something other than the above.

163. (1.20) The basic mechanism for almost all learning is the

A. simple reflex. **B.** peripheral nervous system.
C. autonomic nervous system.
D. conditioned reflex. **E.** medulla oblongata.

164. (1.20) Four of the following are external receptors. Which one would be classified in the category of internal receptors?

A. Semi-circular canals of the ear. **B.** Taste buds.
C. Olfactory nerve endings in the nose.
D. Pain spots in the palm of the hand.
E. The retinas of the eye.

165. (1.20) Which one of the following belongs to the central nervous system?

- **A.** A rod or a cone in the retina of the eye.
- **B.** A connecting neuron in the spinal cord.
- **C.** The nerve ending in a taste bud.
- **D.** A cold spot on the back of the hand.
- **E.** A terminus of the olfactory nerve in the nasal membrane.

166. (1.20) Which of the following is a function of a synapse?

- **A.** To receive sensory stimuli.
- **B.** To regulate the metabolic activities within the nerve cell.
- **C.** To determine the direction that the nerve impulse takes in the nerve circuit.
- **D.** To send out motor impulses in the nervous system.
- **E.** To regulate voluntary activities of the body.

167. (1.20) Dogs are color blind but can be taught to distinguish a red light from a green light on the basis of

- **A.** their sense of smell.
- **B.** the difference in number of infra-red heat rays coming from the two kinds of light.
- **C.** the difference in intensities of the two kinds of light.
- **D.** an instinctive sense which man does not possess.
- **E.** a radar-like phenomenon similar to that found in bats.

168. (1.20) A living nerve may be artificially incited to stimulate a muscle by

A. touching it with a hot glass rod. **B.** pinching.
C. touching it with a crystal of salt.
D. an electrical current. **E.** any or all of the above.

169. (1.20) The major part of the force developed by actively extending one's arm comes from

- **A.** the contraction of a muscle.
- **B.** the lengthening of a muscle.
- **C.** a combination of muscular push and pull.
- **D.** contraction of tendons and ligaments.
- **E.** lengthening of tendons and ligaments.

170. (1.20) Our ears fail to give us information about which one of the following?

- **A.** Rate of motion in a straight line.
- **B.** Change in the rate of motion in a straight line.
- **C.** Change in the rate of motion in a circle.
- **D.** Variations in intensity (loudness).
- **E.** Differences in the intensities of a series of simultaneously sounded pure tones.

171. (1.20) Adjustments of size of skin blood vessels, to greater or lesser flow, can be most easily obtained by respectively heating or cooling blood which flows to

A. cerebral cortex. **B.** thalamus. **C.** cerebellum.
D. medulla oblongata. **E.** spinal cord.

172. (1.20) Which of the following is out of proper order?

A. Taste bud. **B.** Efferent nerve. **C.** Brain.
D. Afferent nerve.

173. (1.20) The action of an anesthetic on the medulla is

A. greater than **B.** less than **C.** same as
the action of the same anesthetic on the cerebrum.

174. (1.20) The number of nerve cell bodies in the gray matter of the spinal cord is

A. greater than **B.** less than **C.** same as
the number of nerve cell bodies in the white matter.

175. (1.20) The velocity of a nerve impulse produced in response to a weak stimulus is

A. greater than **B.** less than **C.** same as
the velocity of the nerve impulse produced by a very intense stimulus.

Items 176 - 179. What combination of results will follow each of these operations?

176. (1.20) The dorsal root of a spinal nerve has been cut between the dorsal root ganglion and the spinal cord.

177. (1.20) The dorsal root has been cut between the ganglion and its spinal nerve.

178. (1.20) The ventral root has been cut.

179. (1.20) The spinal nerve has been cut.

Results:

- **A.** Degeneration of axons extending into the spinal cord.
- **B.** Degeneration of axons in spinal nerve.

C. Degeneration of dendrites in spinal nerve.
D. Loss of sensation. **E.** Paralysis.

Combinations: (Mark your answer sheet on the basis of these.)

(1) **A** and **B** (2) **A** and **D** (3) **B** and **E**
(4) **B, C, D,** and **E** (5) **C** and **D**

180. (1.20) Which of the following is the major function of receptors?

A. They control the automatic functions of the body.
B. They produce responses after stimuli have been received.
C. Their major function is to coordinate stimulus and response.
D. They give organisms sensitivity to their environment.
E. Their function is unknown.

181. (1.20) Our ears fail to give us information about which one of the following?

A. Rate of motion in a straight line.
B. Change in the rate of motion in a straight line.
C. Change in the rate of motion in a circle.
D. Variations in intensity (loudness) of a single pure tone.
E. Differences in the intensities of a series of simultaneously sounded pure tones.

182. (1.20) When a paramecium is cut in half, the hind half rotates in the same way as does the front half. What does this mean?

A. Rotation depends on the shape of the anterior end.
B. Rotation depends on the obliquity of the oral groove.
D. Rotation depends on the shape of the gullet.
D. Rotation depends on the arrangement of the cilia.
E. Rotation depends on on the direction of beat of the cilia.

183. (1.20) The number of axones in succession along which a nerve impulse must pass *from* the central nervous system *to* reach the organ stimulated is

A. greater for a somatic than a visceral reflex.
B. greater for a visceral than a somatic reflex.
C. the same for both visceral and somatic reflexes.
D. sometimes greater, sometimes less for a somatic than for a visceral reflex, depending on the organ innervated.

184 - 188. Select the answer to each of these items from the key list below.

KEY

A. Pons. **B.** Cerebellum. **C.** Cerebrum.
D. Medulla. **E.** Thalamus.

184. (1.20) Which part of the brain is primarily concerned with third-level responses?

185. (1.20) Which part of the brain joins the spinal cord?

186. (1.20) Which part of the brain acts as a bridge for nervous impulses from lower to higher centers?

187. (1.20) To which part of the brain are sensations from the semicircular canals primarily routed?

188. (1.20) Which part of the brain controls body temperature?

189 - 192. In answering the following questions select the appropriate answer from the key list given below.

KEY

A. Cornea. **B.** Crystalline lens. **C.** Retina.
D. Iris. **E.** Optic nerve.

189. (1.20) In which of the structures are rod and cone cells present?

190. (1.20) What structure regulates the amount of light passing to the sensory part of the eye?

191. (1.20) What structure mentioned refracts light so as to form an image on the sensory part of the eye?

192. (1.20) What structure is responsible for the blind spot?

193 - 196. From the key list below, select the most appropriate answer for each of the following items.

KEY

A. Cochlea. **B.** Semicircular canals.
C. Middle ear. **D.** External ear. **E.** Inner ear.

193. (1.20 There is a tubular connection between the pharynx and________.

194. (1.20) Which receives static sensations?

195. (1.20) Moveable bones are found in________.

196. (1.20) If one were to descend rapidly in an elevator, pressure would change first in________.

197. (1.20) Adjustments of size of skin blood vessels, to greater or lesser flow, can be most easily obtained by respectively heating or cooling blood which flows to

A. cerebral cortex. **B.** thalamus. **C.** cerebellum.
D. medulla oblongata. **E.** spinal cord.

198. (1.20) The velocity of an electrical impulse along a wire is

A. greater than **B.** less than **C.** same as
the velocity of a nerve impulse along a nerve.

199. (1.20) The amount of regeneration which takes place in peripheral nerves is

A. greater than **B.** less than **C.** same as
the amount of regeneration which takes place in the spinal cord.

200. (1.20) Precision of localization of sensations from visceral regions is

A. greater than **B.** less than **C.** same as
precision of localizations of sensations from skin regions.

201. (1.20) Destruction of the non-acoustical structures of the ear almost invariably leads to

A. deafness.
B. inability to discriminate pitch of sounds.
C. death. **D.** disturbances of equilibrium.
E. seasickness.

202. (1.20) The organ of Corti

A. secretes a hormone which regulates calcium metabolism in the body.

- **B.** enables us to sense rotation.
- **C.** secretes a hormone which controls carbohydrate metabolism.
- **D.** translates a mechanical vibration into a nerve impulse interpreted as sound.
- **E.** enables us to sense which way is up and which way is down.

After the exercise number on the answer sheet blacken the one lettered space which designates the most similar structure, condition, or process.

203. (2.10) The function of the retina of the eye.

- **A.** The function of the lens of a camera.
- **B.** The function of the shutter of a camera.
- **C.** The function of the film of a camera.
- **D.** The function of the focusing mechanism of a camera.
- **E.** The function of the device which controls the amount of light entering the camera.

204. (2.20) An impulse initiated in a sensory neuron half-way between the end of the axon and the cell body would travel

- **A.** toward the spinal cord only.
- **B.** toward the receptor only.
- **C.** both ways.
- **D.** in neither direction.

205. (2.20) A one-eyed automobile driver, otherwise normal, is handicapped in all except which one of the following?

- **A.** Sense of perspective.
- **B.** Range of vision.
- **C.** Area obliterated by the blindspot.
- **D.** Color discrimination.
- **E.** Ability to judge speed.

206. (2.20) When a stimulus elicits a simple reflex response the actually observed reflex time is longer than the calculated time to traverse the neurons. Why is the actual time greater than the theoretical calculated time?

- **A.** Additional time is consumed in relaying the message to the brain.
- **B.** The impulse travels progressively slower through each succeeding neuron it encounters.
- **C.** Rate of transmission is slower at the synapses.
- **D.** Nerves, like muscles, get tired and tend to respond slower and slower.
- **E.** None of the above satisfactorily accounts for the discrepancy in time.

207. (2.20) A certain neuron is known to belong to the peripheral nervous system. Which of the following observations of the functioning of this neuron indicates that it is a sensory neuron?

- **A.** Its cell-body comprised part of a ganglion outside the grey-matter of the spinal cord.
- **B.** It conducted impulses from its dendrite to its axon.
- **C.** It entered the cord by way of the ventral root.
- **D.** Impulses left this neuron by way of a synapse.
- **E.** It would conduct an impulse from its axon to its dendrite.

208. (2.20) The feeling of nausea in the stomach which some people experience when making a rapid descent in an elevator arises from stimulated sensory nerve endings in the

- **A.** solar plexus.
- **B.** spinal cord.
- **C.** proprioceptors in the tendons of the muscles.
- **D.** inner ears.
- **E.** endocrine glands.

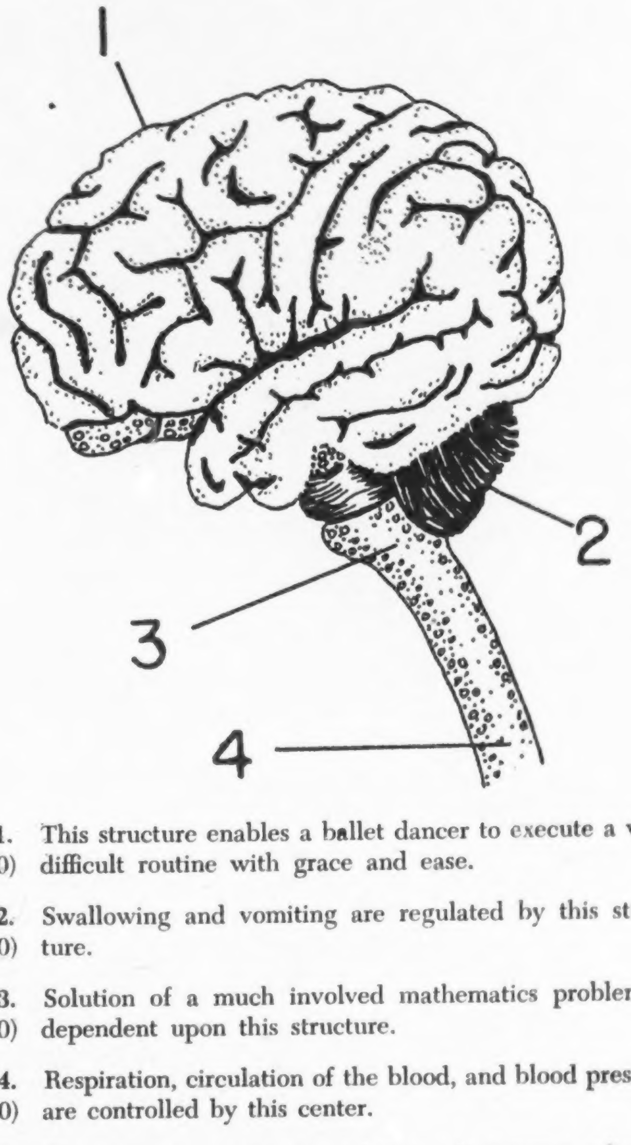
209. (2.20) A person whose retinal cones were defective might have difficulty in

- **A.** trying to distinguish colors.
- **B.** distinguishing pitches of sound.
- **C.** reading a printed page in a textbook.
- **D.** maintaining his equilibrium when attempting to walk.
- **E.** judging distances.

210. (2.20) An upright object perceived by the optic system of the human eye results in an inverted image on the retina, yet we do not "see" objects upside down because

- **A.** eye muscles, controlled by cranial nerves, correct the image position.
- **B.** the medulla, being the lowest portion of the brain, corrects the image orientation.
- **C.** the optic lobes are part of the brain.
- **D.** the brain interprets the nerve impulses it receives.
- **E.** the optic nerves cross in the brain.

Items 211 - 220 involve functions or characteristics of certain structures numbered in the following sketch. For each item select the structure referred to and mark the answer space corresponding to its number.



211. (2.20) This structure enables a ballet dancer to execute a very difficult routine with grace and ease.

212. (2.20) Swallowing and vomiting are regulated by this structure.

213. (2.20) Solution of a much involved mathematics problem is dependent upon this structure.

214. (2.20) Respiration, circulation of the blood, and blood pressure are controlled by this center.

215. (2.20) This structure initiates righting adjustments when a person begins to slip on an unnoticed icy spot on the sidewalk.

216. (2.20) The interior of this structure is composed of gray matter which is surrounded on the outside by white matter.

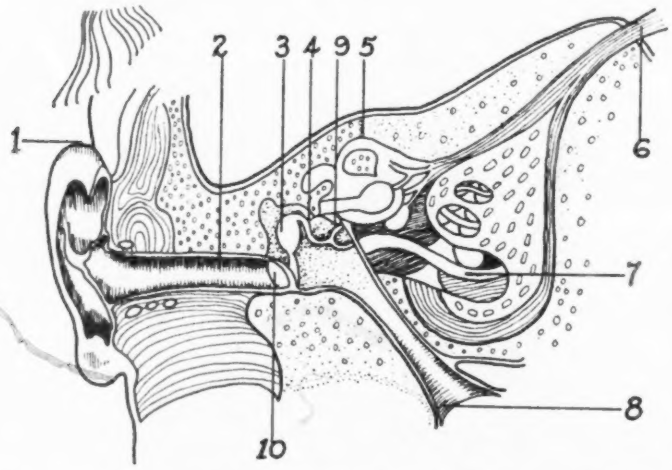
217. This structure is responsible for the sudden removal of
(2.20) the hand from an object touched which turned out to be unbearably hot.

218. If this structure is damaged or destroyed in an experi-
(2.20) mental animal, muscle movements become jerky and decidedly ineffective.

219. This structure is concerned with the interpretation of
(2.20) sight and sound.

220. This structure is involved when creative imagination
(2.20) comes into play as when a composer or an artist creates a new musical composition or an original painting.

After each exercise number on the answer sheet, blacken the one lettered space which designates the part of the diagram to which the item correctly refers.



221. The part which collects air vibrations is indicated by
(2.20)

A. 2. **B.** 10. **C.** 5. **D.** 7. **E.** 8.

222. The part which is made to vibrate by air vibrations is
(2.20) indicated by

A. 2. **B.** 10. **C.** 5. **D.** 7. **E.** 8.

223. The part which enables the air pressure on both sides
(2.20) of the eardrum normally to be kept equal is the.

A. 2. **B.** 10. **C.** 5. **D.** 7. **E.** 8.

224. The part which enables us to become aware of a change
(2.20) in the position of the body is the structure indicated by

A. 2. **B.** 10. **C.** 5. **D.** 7. **E.** 8.

225. The part which contains the organ of hearing is indi-
(2.20) cated by

A. 2. **B.** 10. **C.** 5. **D.** 7. **E.** 8.

226. The part which transmits vibrations from the eardrum
(2.20) to the inner ear is indicated by

A. 3. **B.** 3 and 4. **C.** 3, 4, and 9.
D. 9 and 7. **E.** 10 and 7.

227. The part which connects the middle ear cavity with
(2.20) the upper part of the pharynx is the

A. 2. **B.** 10. **C.** 5. **D.** 7. **E.** 8.

228. The oval window of the inner ear which receives vibra-
(2.20) tions is closely associated with the structure indicated by

A. 2. **B.** 10. **C.** 5. **D.** 7. **E.** 8.

229. The part which the physician must puncture to allow
(2.20) drainage and prompt healing in ear infections is indicated by

A. 2. **B.** 10. **C.** 5. **D.** 7. **E.** 8.

230. The most frequent cause of deafness is the malfunction
(2.20) of the part indicated by

A. 10. **B.** 3, 4, and 5. **C.** 7.
D. 3, 4, and 9. **E.** 5.

(1) "After we have started mechanical irritation of these places" (front and hind leg) "with the pricking apparatus, then acid is poured into the the mouth of the dog. (2) The secretion of saliva produced by the acid is, of course, a simple inborn reflex. (3) This was repeated several times . . . (4). After a number of experiments a state of affairs results in which we get a flow of saliva when we begin only to irritate that spot of the skin; it is just as if we had poured acid into the dog's mouth."

The following items refer to the above quotation. After each exercise number on the answer sheet, blacken the one lettered space which designates the correct answer.

231. Irritation of the front and hind legs sets up impulses
(2.20) that first travel along

A. afferent (sensory) fibers to the spinal ganglion.
B. efferent (motor) fibers to the spinal cord.
C. afferent fibers to the brain.
D. efferent fibers to the salivary glands.
E. afferent fibers to the salivary glands.

232. The "mechanical irritation" referred to in statement (1)
(2.20) first stimulates the

A. medulla oblongata.
B. nerve endings (receptors). **C.** spinal ganglion.
D. axons. **E.** gray matter of the spinal cord.

233. The cell body of the first neuron along which the im-
(2.20) pulses travel is in the

A. gray matter of the spinal cord.
B. white matter of the spinal cord.
C. medulla oblongata. **D.** spinal ganglion.
E. cerebrum.

234. After the impulses leave the first neuron, they must
(2.20) next pass

A. across a synapse.
B. to the axon of a second neuron.
C. from one myelin sheath to another.
D. through white matter. **E.** to efferent neurons.

235. After the impulses, set up by the "mechanical irrita-
(2.20) tion," leave the first neuron, they next travel to the part of the nervous system called the

A. spinal ganglion. **B.** spinal cord.
C. medulla oblongata. **D.** cerebellum.
E. cerebrum.

236. In order for dogs to experience the sensation of touch
(2.20) when their legs are "mechanically irritated," the impulses must eventually reach

A. the gray matter of the spinal cord.
B. in the medulla the center for the control of the heartbeat.
C. the cerebellum. **D.** any part of the cerebrum.
E. the cerebral cortex.

237. The "acid" in the dog's mouth first stimulates the
(2.20)

A. spinal cord. **B.** medulla oblongata.
C. olfactory (smell) cells in the nasal chambers.
D. secretory cells of the salivary glands.
E. taste end organs of the tongue.

238. The secretion of saliva in statement (2) was the result
(2.20) of impulses going to the salivary glands along

A. afferent neurons originating in the brain.
B. efferent neurons originating in the brain.
C. neurons associated with the taste buds.
D. afferent neurons originating in the spinal cord.
E. efferent neurons originating in the spinal cord.

239. The impulse along a nerve fiber involves
(2.20)

A. only electrical changes. **B.** only physical changes.
C. no demonstrable changes.
D. electrical and chemical changes.
E. only chemical changes.

240. In statement (4), the salivary secretion, resulting from
(2.20) stimulation of the skin, only, is known as a(n)

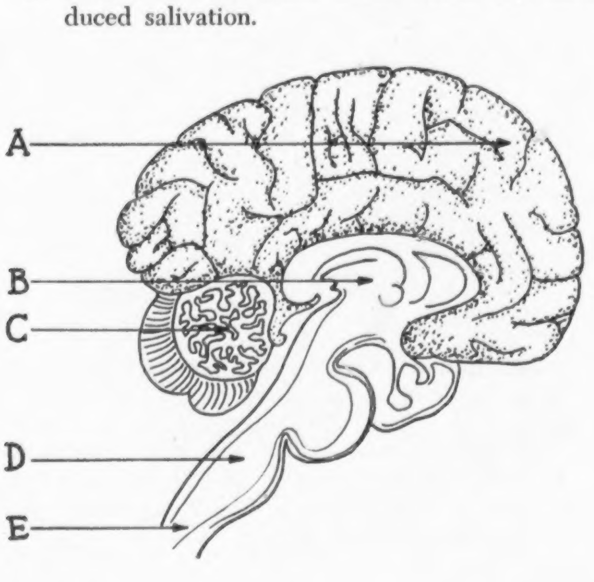
A. conditioned reflex. **B.** simple reflex.
C. inborn reflex. **D.** inherited reflex.
E. reflex arc.

241. Cutting through the central nervous system just in front
(2.20) of the medulla oblongata before the experiment began would have

A. had no effect on the results mentioned in statement (4).
B. prevented the results referred to in statement (4).
C. prevented salivation when acid was added to the mouth, but not when "mechanical irritation" of the limbs took place.
D. demanded more vigorous "irritation" of the limbs before the same response could be elicited.
E. invariably resulted in the death of the dog due to destruction of the breathing center.

242. If Pavlov, at the beginning of the experiment, had
(2.20) substituted the flashing of a strong colored light in the eye of the dogs for mechanical irritation of the fore and hind limbs,

A. flashing of the light alone would probably have resulted in secretion of saliva.
B. flashing of the light alone would have had no effect.
C. flashing of the light would have resulted in salivation only if accompanied by irritation of limb.
D. irritation of the limbs alone would still have produced salivation.



Items 243 - 256 refer to diagram in left column.

243. Contains the centers which regulate and maintain res-
(2.20) piration and circulation.

244. Injury to the anterior region of this area results in
(2.20) symptoms of mental abnormality.

245. The chief role is to maintain coordination and smooth-
(2.20) ness of muscular activity.

246. Contains centers of hearing and speech.
(2.20)

247. Contains centers controlling many involuntary reactions
(2.20) of the viscera.

248. Injury to this area will result in disturbances in the
(2.20) temperature regulation of the body.

249. Contains centers of perception of body sensations such
(2.20) as heat, cold, and touch.

250. Consists largely of ascending or sensory and descending
(2.20) or motor pathways.

251. Has relatively more gray matter than any other brain
(2.20) part.

252. Contains the centers associated with equilibrium.
(2.20)

253. The region where many sensory fibers from the spinal
(2.20) cord synapse with sensory neurons.

254. Contains centers which are associated with heat regula-
(2.20) tion, vomiting, and nausea.

255. Associated with centers of intelligence and conscious-
(2.20) ness.

256. The place of synapse of sensory and motor neurons
(2.20) associated with the appendages.

After the number on the answer sheet which corresponds to that of each of the following paired items, blacken space

A if the item in Column I is true and its truth is supported by the item in Column II.
B if the item in Column I is true, but the item in Column II, although true in itself, neither supports nor disproves the item in Column I.
C if the item in Column I is true, but the item in Column II is false.
D if the item in Column I is false and the item in Column II is false.
E if both items are false.

	Column I		*Column II*
257. (2.20)	Cutting across the dorsal root of spinal nerve results in loss of feeling of the part involved.	....	Impulses are unable to pass to the spinal cord and thus to the brain.
258. (2.20)	Even though a stimulus is weak, if it is adequate, it will set up an impulse in a sensory fiber.	....	When the pressure on the trigger of a revolver is great enough, the bullet is discharged.
259. (2.20)	Within the body, axones normally carry impulses in one direction only: away from the cell body of a neuron.	....	Axones are protoplasmic and are capable of transmitting impulses.

260. (2.20)	Injury to the cerebellum results in jerky voluntary muscular movements.	.... The cerebellum has centers that regulate the heart beat, diameter of blood vessels, and breathing rate.
261. (2.20)	Although the brains of frogs and men have the same five subdivisions, man is the more intelligent.	.... Man has a proportionately larger and more complex cerebrum.
262. (2.20)	The distribution of neuron cell bodies and sheathed neuron fibers in the spinal cord and cerebrum is the same.	.... The cell bodies of the cerebrum are on the outside and those of the spinal cord are on the inside.
263. (2.20)	Impulses originating from the motor area on the right side of the cerebrum cross over the left side of the body.	.... Most people are right-handed.
264. (2.20)	The retina is the light sensitive part of the eye.	.... The retina is the only part of the eyeball that has sensory cells.
265. (2.20)	The semicircular canals of the inner ear are sensitive to high-pitched sounds.	.... The semicircular canals have cells sensitive to high frequency sounds.
266. (2.20)	Oversecretion by the anterior pituitary in childhood may result in giantism.	.... The anterior pituitary secretes a growth hormone.
267. (2.20)	Undersecretion by the thyroid in an adult results in loss of weight.	.... Oversecretion of thyroxin increases the rate of metabolism.
268. (2.20)	Secretin is responsible for stimulating the pancreas to pour pancreatic juice into the duodenum.	.... Secretin is directly responsible for the normal storage of sugar.
269. (2.20)	Removal of both adrenals results in death.	.... Adrenin is a hormone that causes the heart to beat more rapidly, the blood pressure to rise, the pupils of the eyes to dilate, and the air passages to the lungs to open more widely.
270. (2.20)	Insulin cures diabetes.	.... Insulin is a hormone which regulates the concentration of the sodium, chlorine, and potassium ions of the blood.
271. (2.20)	If a geranium plant is lighted from the side, the leaves grow toward the light.	.... Leaves love the light.

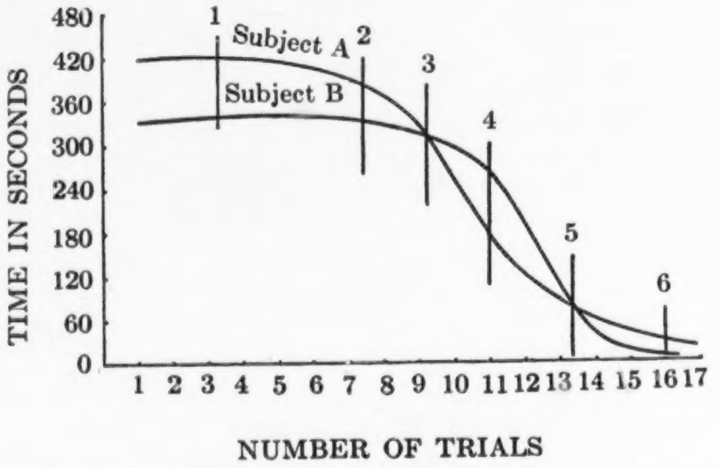
272. (3.00) A dog and a frog sitting on the brink of a 100-foot precipice are both unsuspectingly prodded lightly on the back. The frog jumps headlong into the abyss below, but the dog recovers from his surprise in time to thwart his first impulse to jump blindly forward. The difference in response of these two animals to the same stimulus can be explained, at least in part, by the fact that

A. the dog possesses an endocrine system, while the frog does not.
B. the dog has a more complex cerebrum.
C. the dog's behavior is instinctive, while the frog's behavior is rational.
D. the dog would be more likely to get hurt by a 100-foot fall than would the frog.
E. the frog has a better sense of equilibrium than the dog, consequently the frog doesn't hesitate to jump.

273. (3.00) In an experiment, a rabbit was held out to a child who showed no fear but reached out to take the rabbit. At this instant a loud rasping noise was sounded close to the child's ear; and the child quickly withdrew his hand with signs of fear. When this procedure had been repeated a number of times, the child shrank from the rabbit without further repetition of the noise. This is an example of

A. the development of fear through maturation.
B. conditioning of an emotional response.
C. law of trial and error.
D. learning with insight. **E.** none of the above.

Items 274 - 277 involve interpretation of the following graph which shows the rate at which two people learned to assemble a puzzle.



Note: Positions 1, 2, 3, 4, 5, and 6 are designated above the lines.

274. (3.00) For subject A learning proceeded at the greatest rate at position

A. one. **B.** two. **C.** four. **D.** five. **E.** six.

275. (3.00) At which position are both subjects learning at most nearly equal rates?

A. One. **B.** Two. **C.** Three. **D.** Four. **E.** Five.

276. (3.00) At which position have both subjects attained most nearly the same degree of learning?

A. One. **B.** Two. **C.** Three. **D.** Five. **E.** Six.

277. (3.00) Which of the following is the most valid conclusion to be drawn from the above data?

A. Subject A has a higher I.Q. than Subject B.
B. Subject B has a higher I.Q. than Subject A.
C. Subject B had more previous experience with puzzles than Subject A.

D. Neither subject can be expected to show marked improvement with more practice.
E. Subject A is more mechanically minded than Subject B.

Read the selection carefully. From *Mouse City*, J. C. Calhoun; PARADE, Nov. 26, 1950; by permission.

Dr. John C. Calhoun has spent a year observing mice awake and asleep, at work and at play, in "Mouse City." He has found that under certain conditions the behaviour of mice gives him a clue of what to expect from human beings.

At "Mouse City," Dr. Calhoun built apartments for families of both aggressive and nonaggressive mice. Then he watched them as they sought the everyday needs of mice and men: food, water, and a place to live.

He discovered that mice develop different degrees of tolerance toward each other, depending on the genetic strain. In some strains all members live happily without serious fights over food, water, or lodging. Other strains obviously don't like each other. They fight all the time, usually for the privilege of being ahead of the other fellow. A mouse is often chased from his feeding by an intruder where there is plenty of room for both of them.

In "Mouse City" Dr. Calhoun built "stairways" leading to each of the four floors of his apartment houses. Weaker mice were chased up the stairs to the top floor apartments by their stronger and more aggressive brothers, and lived in an inferior social world. Those that occupied apartments near the source of food and water became "Mouse City's" social leaders.

"If this pattern proves to be the general rule," says Dr. Calhoun, "it will mean that mice of different social rank move through their environment in different ways."

Directions: For each of the following items select the best answer and mark the corresponding space on the answer sheet.

278. The statement, "He has found that under certain conditions the behavior of mice gives him a clue of what to expect from human beings" is
(3.00)

A. one which reflects a position that a scientist might take.
B. one which reflects a position such as no scientist would take.
C. one based on a false assumption that men and mice have basically similar behavior.
D. valueless because you can only learn about people by experimenting with people.
E. valueless because you cannot place mice under conditions corresponding to those under which human beings live.

279. The statement in item #278 is based on the concept that
(3.00)

A. all life arises from pre-existing life.
B. all living matter consists of protoplasm.
C. all living organisms consist of cells or the products of cells.
D. man is an animal related to other animals.
E. animals differ from man in that they lack his highly developed nervous system.

280. The statement in item #278 is further based on the concept that
(3.00)

A. mammals have many characteristics in common.
B. human society contains all kinds of people.
C. human social forms have arisen through evolution.
D. mice and human beings are basically different both physically and mentally.
E. man has a more highly developed brain than a mouse.

281. The statement in item #278 is further based on the assumption that
(3.00)

A. one can achieve acceptable results only through experimentation.
B. under similar conditions comparable results may be expected.
C. anything which a scientist does may be accepted as valid.
D. scientists generally work on problems that lead to social betterment.
E. observation may be substituted for experimentation.

282. Which of the following constitutes the best statement of Dr. Calhoun's problem?
(3.00)

A. How do mice behave under conditions similar to those found in human society?
B. What characteristic behavior patterns do human beings display in social situations?
C. How can a better human society be built?
D. What elements of behavior are common to mammals in general?
E. How do mice compare anatomically with human beings?

283. The statement, . . ."that mice develop different degrees of tolerance toward each other, depending on the genetic strain," is
(3.00)

A. an observation.
B. a generalization based on observation.
C. evidence in support of a generalization.
D. an assumption.
E. evidence in support of an assumption.

284. The statement in item #283, if accepted as true, and read in context with the remainder of the article, indicates that
(3.00)

A. heredity plays no part in determining social behavior of mice.
B. environment plays no part in determining social behavior of mice.
C. heredity interacts with environment in determining social behavior of mice.
D. it is impossible to determine whether or not environment enters into the determination of social behavior of mice.
E. it is impossible to determine the part that heredity plays in the determination of social behavior of mice.

The following is a description of an experiment. Read it through and answer the questions which follow it.

To see an electric record of a nerve impulse, we usually dissect a frog nerve, and place it on two pairs of electrodes hooked up to an oscilloscope which records the transmission of an electric current. Brief electric shocks of gradually increasing strength are applied to the nerve. When the stimulus reaches a certain strength known as the "threshold," we suddenly see an electric wave recorded on the oscilloscope . . . If we strengthen the electric stimulus, the strength of the impulse transmitted by the nerve will also increase, up to a certain maximum. This would suggest that the response of a nerve may vary in degree. But the frog nerve is made up of thousands of small nerve fibers, packed tightly together in a bundle . . . Physiologists suggested that the variable response might be due to variation in the number of fibers brought into play; they argued that an individual nerve fiber probably responded in an "all or nothing" fashion.

Recently the physiologist R. W. Gerard and his colleagues have studied the responses of single nerve fibers without dissecting them, by using as electrodes, submicroscopic micropipettes inserted into a small individual fiber. If we insert the tip of a micropipette into the surface of the fiber and apply a brief electrical stimulus, we find that up to a certain strength there is no response. But as soon as the strength of the stimulus exceeds the "threshold" of our fiber, we observe a large electrical wave. Now no matter how much we increase the strength of our stimulus, the size of the electric response is always exactly the same. It is either there in full strength or not there at all.

After the number on the answer sheet corresponding to that of each statement, blacken space

A if the statement is true on the basis of evidence given in the passage.
B if it is true, on some basis other than the passage.
C if the statement is false on the basis of evidence given in the passage.
D if the statement is false, on some basis other than the passage.

285. (3.00) The response of a single nerve fiber may vary in degree, depending on the strength of the stimulus.

286. (3.00) Variation in response of a nerve to stimuli of different strengths is due to the fact that different numbers of nerve fibers are stimulated.

287. (3.00) The question of what causes the variation in response of the nerve can be settled by studying the reaction of a single isolated nerve fiber in comparison with the response of a nerve.

288. (3.00) The individual fiber probably responded in an "all or nothing" fashion—as a match, on being struck, either lights or does not light, depending on whether it has reached the kindling point.

289. (3.00) Nerve cells possess an electric charge.

290. (3.00) The nerve impulse is an electric charge transmitted along a nerve fiber.

291. (3.00) All nerve fibers are the axones of nerve cells.

292. (3.00) There are two main classes of nerve fibers: one kind enclosed in a "medullary" sheath, and the other lacking such a sheath.

293. (3.00) All nerves are motor nerves.

294. (3.00) A reflex may consist of only two neurons, a sensory and a motor neuron.

After each item number on the answer sheet, blacken the one lettered space which designates the correct answer.

295. (3.00) After recovering from an automobile accident, the victim discovered that he was blind in the right half of each eye. In all probability this was due to the injury of the

A. back part of both cerebral hemispheres.
B. back part of the right cerebral hemisphere.
C. back part of the left cerebral hemisphere
D. left half of the medulla.
E. right half of the medulla.

296. (3.00) Rays of light come to a focus in front of the retina and are also irregularly bent by the surface of the lens or cornea. The eye described needs correction for

A. nearsightedness and astigmatism.
B. farsightedness and astigmatism.
C. nearsightedness and myopia.
D. astigmatism only. **E.** myopia only.

297. (3.00) Some farmers keep their livestock in the pasture by using a very simple device known as an electric fence. This consists of a single wire strung on widely-spaced posts. At periodic intervals an electric current strong enough to produce a startling shock is sent through the wire. When a horse or a cow has received this shock several times it scrupulously avoids getting close enough to the wire to touch it. When the fence has been in operation for some weeks it is often possible for the farmer to shut the current off for days at a time with no attempt on the part of the livestock to get out of the fields. This is due to a phenomenon known as

A. automatic response. **B.** crossed extension.
C. conditioned reflex. **D.** differential inhibition.
E. innate reflex.

298. (3.00) Some research workers suspended—by a single centrally attached cable—a huge steel beam weighing many tons, in such a manner that it hung in perfect balance. One end of the beam was subjected to repeated rhythmic bombardment by a small cork. For many minutes no noticeable effect was apparent. After prolonged, sustained, rhythmic impact by the cork, however, the beam began to sway and finally it toppled out of balance. The analogy corresponds to the aspect of a reflex response in the nervous system which is known as

A. susceptibility to adverse conditions.
B. irreversibility of conduction.
C. long latent period. **D.** long after-discharge.
E. summation of sub-minimal stimuli.

Items 299 to 303 involve the following report of an experiment.

1) Crustacea possess small cavities through which water flows and in which a few sand grains usually accumulate. 2) An investigator, after he had placed iron particles in the cavities usually containing sand of some of the crayfish and silver particles in the cavities of others, moved a magnet around the aquarium in which the crustacea were swimming. 3) These particular specimens had been given the investigator by a teacher who had observed them to swim in a drunken fashion shortly after the teacher had allowed a strong current of water to flush through the aquarium in which she kept the crustacea. 4) The investigator had noticed that there was no sand in the teacher's aquarium before he began his study. 5) When the magnet was held under the second aquarium the silver and iron carrying crustacea behaved normally, when held beside the aquarium the silver crustacea behaved normally, but the iron crustacea swam on their sides, and when the magnet was held over the aquarium the silver ones were still normal but the iron carrying crustacea swam on their backs.

299. (3.00) Which of the numbered sentences indicates that a problem is being analyzed?

300. (3.00) In which numbered sentence is a hypothesis being formulated?

301. (3.00) Which of the following would be the best statement of the result of this experiment?

A. Crustacea are able to remain swimming in a normal position by responding to the earth's magnetism.

B. Crustacea are able to remain swimming in a normal position by responding to the force of gravity on particles in special cavities in their bodies.
C. Crustacea from which sand particles have been removed and replaced by iron particles will swim in such manner as to keep the iron particles as close to a magnet as possible.
D. If the sand normally found in a special sense organ of crustacea is replaced by iron particles the crustacea will respond positively to the presence of a magnet.
E. Additional investigation should be made on the question of balance maintenance in crustacea before any conclusion can be drawn from this experiment.

302. (3.00) Which of the responses under item number 301 would make the best statement of a conclusion to be drawn from this experiment?

303. (3.00) The investigator's assistant concluded from this experiment that any kind of particles in these special organs would allow a crustacean to swim normally. Before agreeing with him it would be necessary for a true scientist to

A. investigate what other research has reported concerning the behavior of crustacea.
B. consult the assistant's superior for his opinion.
C. repeat the experiment using a variety of kinds and weights of materials on a variety of crustacea under differing conditions.
D. make further investigation into the conditions in which the original crustacea lived in the teacher's aquarium.
E. report the experiment in professional journals to determine what other investigators think of the conclusion reached by the assistant.

304. (3.00) The cutting of the *ventral* half of the spinal cord on the *right* side, midway between arm and leg, will produce greatest damage to

A. sensory stimuli ascending the cord from the right leg.
B. sensory stimuli ascending the cord from the left leg.
C. motor stimuli from the left cerebral hemisphere.
D. motor stimuli from the right cerebral hemisphere.
E. "withdrawal" or flexion reflexes of the right leg.

305. (4.10) The somatic (as opposed to the autonomic) nervous system is primarily concerned with coordinating

A. the homeostatic processes within the organism with each other.
B. the homeostatic processes within the organism to changes in the external environment.
C. the movements of the organism with respect to its environment.
D. all the responses of an organism with changes in its external environment.
E. all the processes which taken together maintain constancy of the internal environment.

18. *Endocrine System—Structure and Function*

ENDOCRINE SYSTEM — STRUCTURE AND FUNCTION

1. (1.10) Which of the following hormones enables the body to store and oxidize sugar?

A. Insulin. B. Adrenalin. C. Secretin.
D. Pituitrin. E. Theelin.

2. (1.10) The islet cells of the pancreas secrete the substance

A. secretin. B. cholecystokinin. C. lipase.
D. protease. E. insulin.

3. (1.10) Insulin directly affects the

A. absorption of sugar by the intestine.
B. storage of sugar.
C. secretion of pancreatic juice.
D. storage of proteins. E. secretion of saliva.

4. (1.10) The hormone secreted by the thyroid gland regulates

A. the sugar content of the blood.
B. the stress mechanism of the body.
C. the rate of metabolism in the body.

5. (1.10) Hypo-secretion of an endocrine gland means

A. too much secretion. B. too little secretion.
C. the wrong type of secretion.

6. (1.10) The anterior pituitary serves as "master gland" for the body by

A. regulating the rate of chemical activity in the body.
B. producing regulating or "tropic" hormones which control other endocrine glands.
C. exercising a generalized control over the activity of the central nervous system.

7. (1.10) The hormone secreted by the adrenal medulla

A. regulates the amount of urine secreted by the kidneys.
B. aids in the development of secondary sex characteristics.
C. aids the body in time of emergency by speeding up the heart rate and other reactions.

8. (1.10) A hormone that affects the body's use of sugar:

A. insulin. B. estrogen. C. pepsin.
D. amylopsin. E. prothrombin.

9. (1.10) Cretinism is a disease characterized by mental and physical retardation caused by a thyroid deficiency. (True or False)

10. (1.10) The hormones produced by the Isles of Langerhans in the pancreas:

A. secretin. B. sympathin. C. auxin.
D. insulin. E. cortin.

11. (1.10) Glands that produce a hormone functioning in calcium metabolism:

A. Thyroids. B. Adrenals.
C. Isles of Langerhans. D. Gonads.
E. Parathyroids

12. (1.10) Diabetes is caused by a lack of

A. sufficient thyroxin secretion.
B. enzyme secretion from the pancreas.
C. enzyme secretion in the stomach.
D. sugar in the blood.
E. sufficient insulin secretion.

13. (1.10) Progesterone is produced by the

A. egg. B. uterus. C. pituitary gland.
D. corpus luteum. E. follicle.

14. (1.10) Estrogen is produced by the

A. egg. B. uterus. C. placenta.
D. corpus luteum. E. follicle.

15. (1.10) Which one of the following is an endocrine gland?

A. Gall bladder. B. Parathyroid.
C. Salivary gland. D. Gastric gland.
E. The enzyme secreting portion of the pancreas.

16. (1.10) Adrenalin facilitates

A. storage of sugar by liver.
B. release of glycogen by liver.

17. (1.10) Adrenalin is secreted by

A. the kidneys. B. the hypophysis.
C. the medulla of the adrenals.
D. the cortex of the adrenals.

18. (1.10) Which of the following fits best the function of the thyroid gland?

A. Regulates blood pressure.
B. Regulates metabolism.
C. Regulates blood calcium.
D. Regulates the formation of blood cells.

19. (1.10) The pituitary gland is a/an

A. endocrine gland. B. exocrine gland.
C. ducted gland. D. unicellular gland.

20. (1.10) The basal metabolic rate is decreased by

A. hyperthyroidism. B. hypothyroidism.
C. exposure to cold. D. exercise.

21. (1.10) The endocrine gland whose hormone most directly affects the rate of cellular respiration is

A. the pancreas. B. the adrenal cortex.
C. the pituitary. D. the thyroid. E. the thymus.

Items 22 - 26. Functions:

A. activation of pepsinogen.
B. activation of trypsinogen.
C. control of sugar concentration of blood.
D. emulsification of fat.
E. stimulation of pancreatic secretion.

With which of the above functions are the following concerned?

22. (1.10) Adrenalin. **23.** (1.10) Bile. **24.** (1.10) Enterokinase.

25. (1.10) Hydrochloric acid. **26.** (1.10) Insulin.

27. (1.10) A hormone can best be defined as

- **A.** any product of an endocrine gland.
- **B.** that which distinguishes an adult male from an adult female.
- **C.** a substance which neutralizes toxins in the blood.
- **D.** an enzyme which is found in blood plasma.
- **E.** a specific substance secreted by one organ with effects on other organs which it reaches via the blood.

In answering items 28 - 36, refer to the key list below.

KEY

A. Adrenalin. **B.** Oxytocin. **C.** Vasopressin.
D. Antidiuretic hormone. **E.** Cortisone.

28. (1.10) Hormone which prevents Addison's disease.

29. (1.10) Pituitary hormone which regulates water balance in the body.

30. (1.10) Hormone which induces contraction of the uterus.

31. (1.10) Hormone which regulates the water, salt, and sugar balance of the body.

32. (1.10) Hormone liberated in the event of unusual energy requirement or emergencies.

33. (1.10) Hormone which contracts the smooth muscles of the gut.

34. (1.10) Hormone which inhibits the contraction of smooth muscles.

35. (1.10) Hormone which is produced by the outer layer of the adrenals.

36. (1.10) Hormone which is produced by the inner layer of the adrenals.

37. (1.10) Calcium concentration in the blood is partially regulated by the

A. thyroid. **B.** anterior pituitary lobe.
C. parathyroid. **D.** posterior pituitary lobe.
E. intermediate pituitary lobe.

38 - 43. Select the one most appropriate answer for each of these items from the key list below.

KEY

- **A.** Androgenic hormone.
- **B.** Follicle-stimulating hormone (FSH)
- **C.** Interstitial-cell-stimulating hormone (ICSH)
- **D.** Luteotrophin. **E.** Progesterone.

38. (1.10) Produces secondary sexual characteristics in males.

39. (1.10) Stimulates production of sperm.

40. (1.10) Causes rapid growth of the follicle.

41. (1.10) Causes follicles to produce estrogens.

42. (1.10) Acts to sustain the corpus luteum.

43. (1.10) Is secreted by a gland that forms in the ruptured follicle.

44. (1.10) Adjustment and coordination in man is controlled and regulated in part by which one of the following?

A. The muscles. **B.** The bones.
C. The appendages. **D.** The endocrine glands.
E. All of the above.

45. (1.20) If the corpus luteum fails, the body of the female lacks

A. progesterone. **B.** estrogen. **C.** cortin.
D. parathormone. **E.** insulin.

For items 46 to 58 select from the key the most appropriate or closely related word.

KEY

A. Island(s) of Langerhans. **B.** Thyroid.
C. Parathyroid. **D.** Adrenal. **E.** Pituitary.

46. (1.20) Abnormal functioning may cause sugar diabetes.

47. (1.20) Regulates the calcium content of the blood.

48. (1.20) Is sometimes called the master gland.

49. (1.20) Insufficient secretion during the early years of growth causes cretinism.

50. (1.20) The hormone produced by the gland is insulin.

51. (1.20) Removal results in muscular spasms (tetany).

52. (1.20) An oversecretion of one hormone from the gland after growth is attained causes acromegaly.

53. (1.20) Insufficient production of one of its secretions during growth leads to dwarfism with normal intellect.

54. (1.20) Certain abnormal functioning causes the eyeballs to bulge.

55. (1.20) Influences the sodium and potassium content of the blood.

56. (1.20) Insufficient secretion in adult life causes obesity with sluggishness of the mind.

57. (1.20) Oversecretion causes nervousness, insomnia, rapid heart beat, and thinness.

58. (1.20) Insufficient secretion of the hormone causes Addison's disease.

59. (1.20) The number of known kinds of hormones secreted by the *thyroid* gland is

A. greater than **B.** less than **C.** the same as
the number of known kinds of hormones secreted by the *pituitary* gland.

60. (1.20) Secondary sex characteristics such as spurs, antlers, and human beard are due to

A. activities of the male sex chromosomes.
B. hormones secreted by the testis.
C. the environment. **D.** sex-linked genes.
E. all of these factors.

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61. (1.20) Four of the following are known to produce hormones. No hormone has as yet been found to be secreted from the

A. testes. **B.** cells in the wall of the small intestine.
C. oat seedling stem tip. **D.** cells of the liver.
E. Graafian follicle.

62. (1.20) An endocrine gland is best described by which one of the following?

A. It discharges its product into a duct or tube which leads the product to its ultimate place of utilization.
B. It produces a secretion which passes directly into the blood.
C. It produces a digestive enzyme.
D. Its secretion nearly always has an almost instantaneous regulatory effect upon the organs of the body stimulated by it.
E. Its secretion is more often detrimental than beneficial to the body.

63. (1.20) Four of the following are known to produce hormones. No hormone has as yet been found to be secreted from the

A. pituitary gland. **B.** islets of the pancreas.
C. cells in the wall of the small intestine.
D. oat seedling stem tip. **E.** cells of the liver.

64. (1.20) The utilization of glucose by the body is governed by the hormone,

A. secretin. **B.** ptyalin. **C.** insulin.
D. sucrase. **E.** lactase.

65. (1.20) The secondary sexual characteristics

A. are limited to reproductive tracts.
B. are chiefly involved in gamete production.
C. are necessary for reproduction.
D. are evident in all species of living organisms.
E. depend upon hormone activity.

66. (1.20) An endocrine gland is distinguished from all other kinds of glands in the body in that the endocrine gland

A. discharges its secretion into a special duct or tube which leads the secreted substance to the place where it will produce its characteristic effect.
B. produces a product which passes directly into the blood or lymph.
C. produces an enzyme.
D. produces a substance whose effect is comparable to that of a cleaning fluid.
E. is lined with epithelial cells.

Items 67 - 85. After each number on the answer sheet, blacken space

A if the item refers to the adrenal gland.
B if the item refers to the pituitary gland.
C if the item refers to the thyroid gland.
D if the item refers to more than one of the above glands.
E if the item refers to none of the above glands.

67. (1.20) Functions in reproduction.

68. (1.20) Deficient secretion beginning in infancy results in the retardation of physical, mental, and sexual development known as cretinism.

69. (1.20) Enlargement of this gland is called a goiter.

70. (1.20) Secretion of this gland controls calcium content of the blood.

71. (1.20) Consists of two parts—cortex and medulla, each part producing its own distinct hormones.

72. (1.20) Is sometimes referred to as the "master gland" of the body.

73. (1.20) Removal of the gland brings on evidence of abnormal function.

74. (1.20) Over-secretion causes an abnormal increase in the rate of metabolism.

75. (1.20) One of its hormones stimulates the growth of the bones.

76. (1.20) Deficiency of its hormone causes a disease called sugar diabetes.

77. (1.20) Produces substances which may stimulate cells some distance from the gland.

78. (1.20) The hormone produced by this gland has been synthesized and can be administered by mouth in the form of pills, since it is not destroyed by the digestive juices.

79. (1.20) The malfunctioning of this gland may be diagnosed by a basal metabolism test.

80. (1.20) One of its hormones is thought to have an "emergency" function, causing more rapid heartbeat, increased blood pressure, increase in blood sugar, and more rapid clotting of the blood.

81. (1.20) Lack of secretion of one of its hormones results in disturbed salt balance in the body.

82. (1.20) One of its hormones stimulates the development and maturity of the sex organs.

83. (1.20) The secretion of this gland is discharged directly into the blood.

84. (1.20) Its hormones stimulate the contraction of the gall bladder.

85. (1.20) This gland produces hormones which stimulate some of the other endocrine glands.

"In summary, there is abundant evidence to indicate that the adrenal cortex is of fundamental importance in the metabolic complex of diabetes mellitus. That disease which seemed for a brief time to be so near to being a solved problem at the time that insulin first became available, has yielded very slowly to the combined efforts of scores of investigators. Anything approaching a complete understanding still seems far off, but increasing attention to the complete biochemical integration of the endocrine system provides real hope for solution of the problems which still remain."

E. S. Gordon, *The Adrenal Cortex in Diabetes Mellitus*, Pituitary-Adrenal Function, R. C. Christman (Ed.). By permission of the American Association for the Advancement of Science.

Items 86 - 99. For each of the items, blacken space

A if the statement is true on the basis of evidence given above.
B if the statement is true, but not on the basis of evidence given above.

C if the statement is false on the basis of evidence given above.
D if the statement is false, but not on the basis of evidence given above.

86. The adrenal cortex is part of a gland that in man is
(1.20) located next to the kidney.

87. Diabetes is a disease that is readily cured by the use of
(1.20) insulin.

88. Insulin is one of the hormones secreted by the adrenal
(1.20) cortex.

89. Diabetes mellitus is a disease in which all the sugar in
(1.20) the blood is converted into glycogen.

90. A function of one of the hormones of the adrenal cortex
(1.20) is the regulation of the sodium, potassium, and other salts of the blood.

91. The problem of diabetes mellitus is completely solved.
(1.20)

92. The rate of the heartbeat is affected by impulses coming
(1.20) from the medulla of the brain.

93. Removal of the adrenal cortex results in giantism.
(1.20)

94. The problem of diabetes mellitus will be solved when
(1.20) the function of the adrenal cortex is completely understood.

95. The adrenal cortex is involved in diabetes mellitus.
(1.20)

96. Diabetes mellitus will be better understood when we
(1.20) know more about the adrenal cortex.

97. The endocrine system of man includes the pituitary,
(1.20) gonads, and duodenum.

98. Endocrine glands are glands having a flask shape.
(1.20)

99. Endocrine glands are those lacking ducts.
(1.20)

100. The final stages of the development of the mammary
(1.20) gland is brought about during pregnancy by the hormone

A. secretin. **B.** lecithin. **C.** prolactin.
D. precipitin. **E.** amylopsin.

Evaluate items 101 - 104 according to the following key.

KEY

A. True only of vitamins.
B. True only of hormones.
C. True only of enzymes.
D. True only of two, but not all the above.
E. True of hormones, vitamins, and enzymes.

101. Specific in action.
(1.20)

102. Occur and function both in plants and in animals.
(1.20)

103. Capable of speeding up or slowing down normal body
(1.20) activities.

104. Must be included in animal diets.
(1.20)

105. Of the following the one that has the most remote effect
(1.20) upon digestion is

A. hydrochloric acid. **B.** saliva. **C.** bile.
D. rennin. **E.** thyroxin.

106. Which of the following hormones insures that an adequate supply of enzymes is present in the small intestine
(1.20) at the time that food is arriving there to be digested?

A. Secretin. **B.** Pituitrin. **C.** Theelin.
D. Insulin. **E.** Adrenalin.

Items 107 - 118. After each number on the answer sheet, blacken space

A if the item is true for the pituitary gland.
B if the item is true for the thyroid gland.
C if the item is true for the adrenal glands.
D if the item is true for the parathyroid glands.
E if the item is true for the pancreas.

107. Regulates the rate of oxidation in all body cells.
(1.20)

108. Removal or destruction results in Addison's disease.
(1.20)

109. Is called the "master gland" because it regulates the
(1.20) thyroid, gonads, and adrenal cortex.

110. Controls metabolism of sugar.
(1.20)

111. Regulates calcium metabolism.
(1.20)

112. Produces a hormone that causes the heart to beat more
(1.20) rapidly and blood pressure to rise.

113. Removal of outer layer of gland causes death.
(1.20)

114. Regulates bone and body growth.
(1.20)

115. Secretes a hormone that is an amino acid whose mole-
(1.20) cules contain four atoms of iodine.

116. Consists of an anterior and posterior lobe.
(1.20)

117. Removal causes muscle tetany.
(1.20)

118. Situated on a stalk in the center of the brain.
(1.20)

119. A product obtained from seaweed may be administered
(1.20) to alleviate deficient secretion by which one of the following?

A. Thyroid. **B.** Corpus luteum.
C. Parathyroids. **D.** Adrenals. **E.** Pituitary.

120. Why is insulin aptly named?
(1.20)

A. It is a self-perpetuating substance.
B. Its function is to isolate toxin-producing microorganisms in the body.
C. It serves the same heat-conserving function as insulation.
D. It is produced by clusters of cells which resemble islands.
E. It is produced in an isolated portion of the body.

121. (1.20) How is an increased supply of energy made available to the skeletal muscles during fright?

A. The heart and surface blood vessels contract very markedly.
B. The visceral capillaries contract and the skeletal muscle capillaries dilate.
C. There is increased digestive activity to provide additional blood sugar for the emergency.
D. The blood vessels of the visceral organs relax while the blood vessels of the skeletal muscles contract.
E. In emergency situations the body oxidizes adrenalin instead of glucose to secure a quick supply of energy.

122. (1.20) Simple goiter could be prevented most easily by which one of the following means?

A. By adding small traces of iodine to the diet.
B. By administering periodic treatments with penicillin.
C. By adding vitamin B_2 to the diet.
D. By raising the blood calcium level by drinking milk.
E. By getting sufficient daily exercise to stimulate proper blood circulation.

123. (1.20) Which of the following hormones is NOT a pituitary hormone?

A. Luteinizing hormone.
B. Follicle-stimulating hormone. **C.** Prolactin.
D. Growth hormone. **E.** Progesterone.

124. (1.20) The concentration of insulin in the blood of a diabetic is

A. greater than **B.** less than **C.** same as
the concentration of insulin in the blood of a non-diabetic.

125. (1.20) The concentration of sugar in the renal artery of a diabetic is

A. greater than **B.** less than **C.** same as
the concentration of sugar in his renal vein.

126. (1.20) During rest the amount of adrenalin in the blood leaving the adrenals is

A. greater than **B.** less than **C.** same as
the amount of adrenalin in the blood leaving the adrenals during exercise.

127. (1.20) Malfunctioning of which of the following organs may result in calcification of the kidney?

A. Adrenals. **B.** Pituitary. **C.** Thyroid.
D. Parathyroid. **E.** Ureter.

128. (1.20) Extracts from which of the following organs cause precocious growth when fed to rats?

A. Pituitary. **B.** Adrenals. **C.** Thymus.
D. Pineal body. **E.** Parathyroid.

129. (1.20) Which organ (organs) is (are) known to be both exocrine (with ducts) and endocrine?

A. Pancreas. **B.** Pituitary. **C.** Salivary glands.
D. Spleen. **E.** Pineal body.

130. (1.20) Gigantism is the result of the abnormal functioning of the

A. pancreas. **B.** adrenals.
C. anterior lobe of the pituitary.
D. posterior lobe of the pituitary. **E.** thyroid.

131. (1.20) Which of the following structures does *not* have an endocrine function?

A. Tonsil. **B.** Thyroid. **C.** Adrenal.
D. Pituitary. **E.** Gonad.

132. (1.20) Normal mentality in children depends upon an adequate secretion of

A. adrenalin. **B.** insulin. **C.** secretin.
D. thyroxin. **E.** parathormone.

133. (1.20) Which gland may be overactive in those individuals who are nervous, thin, highstrung?

A. Adrenal. **B.** Thymus. **C.** Thyroid.
D. Pituitary.

134. (1.20) An overdose of insulin causes twitchings, convulsions, unconsciousness, and even death. These symptoms are due to

A. a subnormal concentration of sugar in the blood.
B. an enormous concentration of sugar in the blood.
C. a lack of glycogen in the blood.
D. a subnormal concentration of calcium ions in the blood.
E. a reduction in blood proteins.

135. (1.20) The cortex of both adrenal glands of an animal are removed.

A. The animal dies.
B. Excess water occurs in the body tissues.
C. Abnormal deposits of calcium occur in the soft tissues.
D. There is a permanent increase in the concentration of blood sugar.
E. A tendency toward intersexuality develops.

Each of the following exercises begins with the description of a causal factor. After the exercise number on the answer sheet, blacken the *one* lettered space which designates an effect of the operation of this factor.

136. (1.20) There is a serious deficiency of thyroxin in a growing child.

A. The child's metabolic rate is increased.
B. A condition known as acromegaly results.
C. Growth is retarded, the abdomen protrudes, and the mentality is that of an idiot.
D. The eyes of the child bulge.
E. True dwarfism and sexual immaturity result.

137. (1.20) There is a normal secretion of parathyroid extract.

A. The kidneys and sweat glands excrete a large amount of water from the body.
B. Growth develops normally.
C. The calcium metabolism of the body is properly regulated.
D. The coronary arteries of the heart are dilated.
E. Gigantism and acromegaly are prevented.

138. (1.20) Secretin is produced by the duodenum.

A. Secretion of gastric juice is stimulated.
B. The production of red blood corpuscles is promoted.
C. Enzyme production of the pancreas is stimulated.
D. More bile is stored in the gall bladder.
E. The kidneys and sweat glands are stimulated to excrete more water.

139. The islet tissue of the pancreas becomes impaired.
(1.20)

A. Carbohydrate digestion is affected.
B. Enzyme production by the pancreas is reduced.
C. The ability of the individual to store or to utilize sugar is decreased.
D. Fat digestion is impossible.
E. Excessive secretion of insulin is most likely to occur.

140. The secretion from the anterior lobe of the pituitary
(1.20) gland in a child is abnormally large.

A. A condition known as acromegaly results.
B. The sex organs mature late.
C. There is a speeding up of growth and gigantism results.
D. The child develops bowed legs, and protruding abdomen, and a large head.
E. The child becomes dull mentally, its skin thickens, and its metabolism slows down.

141. Adrenalin is injected into the blood.
(1.20)

A. The individual is stimulated to fear or anger.
B. The blood pressure, blood sugar, metabolic rate, and body temperature are increased.
C. Lactation is stimulated.
D. The individual is enabled to lift a 500 lb. safe.
E. Abnormal deposits of calcium may occur in the soft tissues.

142. Why is a basal metabolism test useful in diagnosing
(2.20) malfunctioning of the thyroid gland?

A. Increased heart rate is one symptom of thyroid malfunction.
B. Nervous tension is sometimes due to hyperfunction of thyroid.
C. Oxygen consumption is related to the amount of thyroid present.
D. During a basal metabolism test thyroxin production is reduced to a minimum.
E. Self-diagnosis should not be made of an individual's hormone needs.

Items 143 - 158.

Certain of the hormones produced by the anterior lobe of the pituitary gland are well known for their effects upon the ovary. The follicle-stimulating hormone (FSH) and the luteinizing hormone (LH) are examples. These two hormones (FSH, LH) also have an effect when injected into the male. In order to study the hormonal control of the functions of the reproductive tract of the male mammal, the following observations and experiments were made upon a large number of adult male rats. The pituitary gland was removed surgically (such rats are called hypophysectomized). Nothing further was done for two months. In this time, it was noted, the seminiferous tubules of the testes had shrunk considerably and all spermatogenesis (i.e., production of sperms) had stopped. The interstitial cells of the testis, i.e., the cells located between the tubules, had also become reduced in size. In this two months' period the accessory sex organs, such as the prostate gland and the seminal vesicle, had also become much reduced, and appeared to begin a non-secretory state.

Observations:

A. Moderate doses of FSH were injected daily for a period of one month into a large number of the rats. The accessory sex organs remained small and in a non-secretory condition. Testis tubules showed a partial restitution of size and spermatoganic activity. Interstitial cells showed no growth.

B. Moderate doses of LH were injected daily for a period of one month into a large number of the rats. The accessory sex organs grew and resumed their normal level of secretory activity. Testis tubules showed only partial restitution of size and spermatogenic activity. The interstitial cells grew to nearly normal size.

C. Moderate doses of androgenic compounds (that is, male sex hormones) were injected daily for a period of one month into a large number of the rats. Accessory sex organs grew and resumed their normal level of secretory activity. Testis tubules grew but little (including only slight indications of the restoration of spermatogenic activity), and interstitial cells show no growth.

D. Simultaneous injection of moderate doses of FSH and LH daily for a period of one month into a large number of the rats resulted in the complete restoration of testis size, appearance and function, and in complete restoration of size, appearance and function to the sex accessory organs.

E. Simultaneous injection of moderate doses of FSH and androgenic compound daily for a period of one month into a large number of the rats resulted in complete restoration of size, appearance and function of the sex accessory organs and of the seminiferous tubules. The interstitial cells grew but slightly, if at all.

F. Saline solution was injected daily for a period of one month into a large number of the rats. They showed no change in the non-functional condition of the sex accessory organs, or in the size and appearance of the reduced testis.

YOU ARE NOW TO MARK the following conclusions as follows: Blacken answer space:

A. if the conclusion is *warranted* by the observation given above.
B. if the conclusion is *contradicted,* in whole or in part, by the observation given above.
C. if the conclusion *goes beyond* the data presented in the observations given above.

143. In the hypophysectomized rat, injections of male sex
(2.20) hormones are necessary for restoration of normal accessory sex organ function.

144. In the hypophysectomized rat, administration of FSH is
(2.20) sufficient to restore the normal activities of the testis.

145. In the hypophysectomized rat, injections of male sex
(2.20) hormones are sufficient to restore accessory sex organ function to a secretory level.

146. In the hypophysectomized rat, LH injections are suffi-
(2.20) cient to restore the normal activities of the testis.

147. In the hypophysectomized rat, injections of male sex
(2.20) hormones are sufficient to restore normal activities of the testis.

148. In the hypophysectomized rat, injections of FSH are
(2.20) necessary for restoration of normal functional activities of the testis.

149. In the hypophysectomized rat, injections of FSH are
(2.20) necessary to restore normal activities of the testis.

150. In the hypophysectomized rat, injections of FSH are
(2.20) necessary to restore normal activity of the accessory sex organs.

151. (2.20) In the hypophysectomized rat, injections of LH are sufficient to restore the normal activity of the accessory sex organs.

152. (2.20) In the hypophysectomized rat, injections of LH are necessary to restore the normal activity of the accessory sex organs.

153. (2.20) In the hypophysectomized rat, LH had a direct stimulating effect upon accessory sex organs.

154. (2.20) In the hypophysectomized rat, LH directly stimulates the seminiferous tubules.

155. (2.20) In the hypophysectomized rat, injections of androgenic compounds stimulate seminiferous tubules indirectly, by way of the pituitary gland.

156. (2.20) It is likely that interstitial cells of the testis produce male sex hormones.

157. (2.20) It is certain that cells of the seminiferous tubules of the rat produce no male sex hormone.

158. (2.20) The yearly growth of the testis of seasonally breeding mammals is dependent upon seasonal increase in the secretion of pituitary hormones.

159. (3.00) One difference between the effects of the hormone produced by the adrenal medulla and the effects of the sympathetic nervous system is that

- **A.** the organs responsive to the hormone are different from the organs responsive in the nervous system.
- **B.** if the hormone stimulates an organ, the nervous system inhibits it, and vice versa.
- **C.** the effects of the hormone represent homeostatic control of the internal environment, while the effects of nervous stimulation represent responses to changed environmental situations.
- **D.** the effects of the hormone occur in all parts of the body responsive to it; the effects of the nervous system can be more localized.
- **E.** none of the foregoing, since the effects of the two are identical in all respects.

Read the following descriptions of experiments.

Experiment A: The pituitary gland (in the skull) was removed from a number of rats. Subsequent to recovery, many parts of the reproductive system became much reduced in size and ability to function. Operations on other rats which were similar in every respect except that the pituitary was left intact had no such result.

Experiment B: Rats from which the pituitaries had been removed were given injections of pituitary extract. The reproductive systems of these rats were returned to normal (temporarily).

Experiment C: A number of immature female rats were given injections of pituitary substance. Whole pituitary glands were transplanted into other immatures. All these immature females rapidly developed reproductive organs typical of normal adults.

Experiment D: The pituitary gland was removed from a number of rats. Then each of these rats was surgically connected to a normal rat so as to produce a number of "Siamese Twins" (technically known as parabiotics). Subsequent to recovery, blood test showed that large (practically normal) quantities of pituitary substance were present in both animals of each parabiotic pair.

For each of the items 160 - 171 blacken space

- **A.** if it is contradicted in whole or in part by the implications of one or more of the experiments.
- **B.** if the statement is warranted by all or part of the data given.
- **C.** if it goes beyond the inference to be drawn from the preceding experiments.

160. (4.20) Castration (i.e., removal of testes in the males, or ovaries in the females) results in degeneration of the reproductive system.

161. (4.20) Pituitary substance is normally necessary for the continued functioning of the adult reproductive system.

162. (4.20) Only the presence of a normal pituitary gland can prevent degeneration of the reproductive system.

163. (4.20) Sexual immaturity is probably due to the fact that during immaturity the reproductive system is unable to respond to the effects of pituitary substance.

164. (4.20) Pituitary substance can pass from one member of a parabiotic pair to the other.

165. (4.20) Surgical shock involved in operations on the head is apparently sufficient to cause degeneration of the reproductive system.

166. (4.20) The substance produced by the pituitary gland can stimulate growth of the reproductive system.

167. (4.20) Injection of pituitary substance into a senile rat (aged beyond the normal reproductive period) will cause the reproductive system to become (temporarily) functional again.

168. (4.20) The pituitary gland of the average rat is apparently capable of producing more pituitary substance than is required by the average rat.

169. (4.20) The reproductive system of the immature female rat is capable of premature development into an adult condition.

170. (4.20) Once the reproductive system of a female rat has developed to maturity under adequate stimulation by the pituitary gland, removal of the pituitary has little or no effect.

19. Plant Hormones—Their Effect

PLANT HORMONES—THEIR EFFECT

1. A plant hormone:
(1.10)

A. thyroxin. **B.** auxin. **C.** cortisone.
D. insulin. **E.** turgor.

2. Plant hormones are known as
(1.10)

A. aurochs. **B.** auxocytes. **C.** auxochromes.
D. auxins. **E.** auxoamylases.

3. The activities of the living green plant are integrated by
(1.10)

A. light. **B.** CO_2. **C.** hormones.
D. photosynthesis. **E.** nerves.

4. Which one of the following denotes a plant hormone or
(1.10) hormones?

A. Corpus luteum **B.** Auxin. **C.** Acetylcholine.
D. Progesterone.

5. In the following pair, blacken space 1 if the first element
(1.10) of the pair is definitely greater than the second; space 2 if the second is definitely greater than the first; and space 3 if the two are approximately equal.

A. Amount of auxin on the sunny side of a flower stem.
B. Amount of auxin on the shady side of a flower stem.

6. Of the following plant responses, the one which is *not*
(1.20) due to the effect of hormones is

A. turning of the stem in the direction of a light source.
B. wilting of the leaves.
C. wound healing when a portion of the plant is severed.
D. dominance of the terminal bud over the lateral buds.
E. root formation on cuttings.

7. The activities of the living green plant are integrated by
(1.20)

A. light. **B.** carbon dioxide. **C.** nerves.
D. photosynthesis. **E.** hormones.

8. Rooting of stem cuttings can frequently be greatly im-
(1.20) proved by the application of

A. traumatin. **B.** florigen. **C.** sugar solutions.
D. auxins. **E.** antibiotics.

9. Auxin accumulates in the lower region of the stem of a
(3.00) seedling lying horizontal on the ground:

A. Root hairs develop in this region.
B. Cells in this region elongate more rapidly, causing the stem to bend upward.
C. Cell growth in this region is inhibited, causing the stem to bend downward.
D. Dormant lateral buds begin to develop.
E. Brown spots appear where the seedling is in contact with the ground.

Items 10 - 11 are based upon the following experimental data.

Dodder, an orange-colored parasitic plant, twines around other plants and obtains nourishment from them through its tube-like outgrowths from the stem. If it is living upon a long-day plant such as Calendula, it will flower only when the days are long. If it is living upon a short-day plant, such as Cosmos, it will flower only when the days are short.

10. From the foreging evidence, it can be tentatively con-
(3.00) cluded that the dodder

A. is a long-day plant. **B.** is a short-day plant.
C. determines whether its host will be a long-day or a short-day plant.
D. has no stimulative effect on its host.
E. probably obtains hormones which stimulate flowering as well as food from its host.

11. The evidence further suggests that
(3.00)

A. parasites usually destroy their host.
B. enzymes pass from host to parasite.
C. adjustment to a given day-length is fixed for all plants —a plant is either a long-day or a short-day plant.
D. a hormone produced in one plant can effect a change in another plant.
E. the dodder is a very wide-spread menace to crops in the United States.

12. In order to account for the bending of the tip of a stem
(3.00) *toward* light, the auxins produced in the stem tip should

A. collect more on the lighted side of the stem than on the unlighted side.
B. collect more on the unlighted side of the stem than on the lighted side.
C. be distributed without respect to which side is lighted and which unlighted.
D. pass through the sieve tubes toward petioles on the unlighted side of the stem.
E. pass through the sieve tubes toward petioles on the lighted side of the stem.

20. *Asexual Reproduction*

ASEXUAL REPRODUCTION

1. The dividing of a full grown amoeba to form two (1.10) daughter cells is an example of

A. simple fission. B. conjugation. C. budding.
D. mitosis. E. sexual reproduction.

2. Reproduction in the lower organisms by the formation (1.10) of a small replica of the parent as an outgrowth from the body of the parent is called

A. budding. B. binary fission. C. mitosis.
D. amitosis. E. meiosis.

3. Budding occurs or may occur in
(1.10)

A. paramecia. B. spirogyra. C. hydra.
D. bacteria. E. amoeba.

4. The gills of mushrooms are
(1.10)

A. specialized layers bearing basidia.
B. organs of respiration.
C. specialized layers producing poisons.
D. photosynthetic tissues. E. sex organs.

5. Budding as a means of reproduction differs from fission (1.20) in that

A. budding represents asexual reproduction while fission is an example of sexual reproduction.
B. in budding, a plant sends out a long, leafless stem, the tip of which takes root several feet from the parent stem.
C. budding applies only to plants while fission may apply to both plants and animals.
D. the identity of the parent is maintained after budding has occurred, whereas in fission the parent divides to form two offspring.
E. fission requires that the tubers must have "eyes" in order to be productive, whereas budding involves spore formation as a preliminary to reproduction.

6. An example of asexual reproduction would be
(1.20)

A. the fusion of isogametes in the green alga, *spirogyra*.
B. conjugation in paramecia.
C. a potato plant growing from a tuber.
D. an oak tree growing from an acorn.
E. the development of a queen bee from a larva fed a special diet by the workers.

7. Potatoes are usually propagated vegetatively from pieces (1.20) of tuber (underground stem) rather than by seed because

A. the next generation is less likely to include plants which are commercially undesirable.
B. this method reduces the likelihood that fungus parasites will be transmitted to the next generation.
C. plants of the next generation will grow faster.
D. the potato is not a seed plant.

8. In order to make a successful graft
(1.20)

A. the cortex of the scion and stock must be in contact.
B. plants of the same species must be used.
C. the cambium of the scion and stock must be in contact.
D. the scion and stock must be of about the same age.
E. the xylem of the scion and stock must be in contact.

Items 9 - 11. Protozoa reproduce asexually by

A. unoriented binary fission.
B. transverse binary fission.
C. longitudinal binary fission. D. multiple fission.
E. budding.

In which of the above ways do the following reproduce?

9. Amoeba. 10. Paramecium. 11. Malarial parasite.
(1.20) (1.20) (1.20)

Item 12 deleted.

13. The phenomenon of parthenogenesis demonstrates that
(1.20)

A. an egg must be fertilized by a sperm before development is initiated.
B. two full complements of chromosomes must be present in order for an egg to develop.
C. sperm are not always necessary to initiate development of an egg.
D. male reproductive cells alone are capable of developing into mature organisms.
E. development may be initiated in eggs of certain species only by means of artificial stimuli.

14. Production of seedless or parthenocarpic tomato fruits (1.20) can readily be induced by

A. removing the ovules.
B. not allowing pollination to occur.
C. killing the pollen grains.
D. applying auxin to the pistil.
E. removing the anthers.

21. *Sexual Reproduction and Embryology*

SEXUAL REPRODUCTION AND EMBRYOLOGY

1. In animals, meiosis occurs
(1.10)

- **A.** immediately after the egg is fertilized.
- **B.** in the production of the various specialized organs in later embryonic stages.
- **C.** in the production of gametes.
- **D.** in the formation of the mammalian red blood cells in the adult.
- **E.** in all of the foregoing circumstances.

2. The number of chromosomes in a sperm cell is
(1.10)

- **A.** four times the number in the primary spermatocyte.
- **B.** twice the number in the primary spermatocyte.
- **C.** the same as in the primary spermatocyte.
- **D.** one-half the number in the primary spermatocyte.

3. In meiosis, for every primary spermatocyte, the number of sperm produced is
(1.10)

A. one. **B.** two. **C.** four. **D.** eight.
E. dependent on the species.

4. In mitosis,
(1.10)

- **A.** the chromosomes split lengthwise into daughter chromosomes during metaphase.
- **B.** the chromosomes split lengthwise into daughter chromosomes during anaphase.
- **C.** the choromosomes split lengthwise into daughter chromosomes during prophase.
- **D.** the paternal and maternal chromosomes pair and they are separated from each other by the division.
- **E.** the chromatin does not condense into chromosomes but the nucleus constricts into two.

Directions: For each of the following items on the process of cell division, blacken the answer space corresponding to the *one best* alternative.

5. The number of chromosomes per cell typically
(1.10)

- **A.** is constant for all cells in both sexes of a species.
- **B.** is constant for all cells.
- **C.** is constant for somatic cells in a given sex in a species.
- **D.** fluctuates from tissue to tissue within an organism.
- **E.** fluctuates from individual to individual within a species, but is constant for all somatic cells within an individual.

6. Meiosis is important because
(1.10)

- **A.** it halves the chromosome number.
- **B.** it requires two steps.
- **C.** it produces daughter cells.
- **D.** most cells divide mitotically.
- **E.** most growth occurs this way.

7. The determination of sex of the human embroyo is a matter of
(1.10)

A. chance. **B.** the age of the parents at conception.
C. the comparative vigor of the two parents.
D. alkalinity or acidity of seminal fluids.
E. alkalinity or acidity of vaginal fluids.

8. What is ovulation?
(1.10)

- **A.** The production of eggs in the follicle.
- **B.** The surgical removal of a diseased ovary.
- **C.** The implantation of a fertilized egg in the ovary.
- **D.** The escape of a mature egg from the follicle.
- **E.** None of the above.

9. When sperm cells were first examined under the microscope by scientists, these investigators inferred that they were
(1.10)

- **A.** produced in the semiferous tubules.
- **B.** a part of the cellular component of the blood.
- **C.** specialized reproductive cells bearing the half-number of chromosomes.
- **D.** ciliated nuclei bearing chromatin materials.
- **E.** independent organisms present in semen as contaminating material.

After each item number on the answer sheet, blacken space

A if the item is true of blastulation.
B if the item is true of cleavage.
C if the item is true of fertilization.
D if the item is true of gastrulation.
E if the term is true of mesoderm formation.

10. The early mitotic division of the fertilized egg which results in a mass of cells.
(1.10)

11. The arrangement of the embryonic cells into a hollow sphere.
(1.10)

12. The invagination, or growing inward, of one side of the hollow sphere so that a structure of two cell layers results.
(1.10)

13. The process which changes a gastrula into an organism having three primary germ layers.
(1.10)

14. A process which is omitted in case of parthenogenesis.
(1.10)

15. A process which occurs in the development of planaria, but does not occur in that of a hydra.
(1.10)

16. A pollen grain is best defined as a
(1.10)

A. spore mother cell. **B.** male sperm cell.
C. partially developed embryo.
D. partially developed male gametophyte.
E. structure containing endosperm nuclei.

17. A sperm containing genes of one pattern is influenced toward fertilizing an egg of another specific pattern by
(1.10)

- **A.** the acidity or alkalinity of seminal fluid.
- **B.** the acidity or alkalinity of vaginal fluids.
- **C.** the gene pattern within the egg.
- **D.** the presence or absence of the X-chromosome.
- **E.** none of the above.

18. The human embryo has experienced sufficient differentiation of tissues and organs to attain human form after a period of development of about
(1.10)

A. one week. **B.** four weeks. **C.** eight weeks.
D. twelve weeks. **E.** sixteen weeks.

19. (1.10) At some period in their development all mammals are covered with

A. hair. B. feathers. C. spiracles. D. scales.
E. mammary glands.

20. (1.10) A group which characteristically reproduces by internal fertilization is the

A. fish. B. shellfish. C. amphibians.
D. protozoa. E. insects.

21. (1.10) By the term "implantation" is meant

A. the union of sperm and egg to produce a zygote.
B. injection of sperm into the vagina.
C. enzymatic erosion of the uterine wall and attachment of the zygote.
D. removal of tissue from one individual and planting it for growth in another.
E. penetration of the pores or interstitial spaces of one substance by another substance.

22. (1.10) The type of development undergone by the animal embryo is most closely correlated with

A. the method of fertilization.
B. the relative amount and arrangement of yolk in the egg.
C. the habitat of the parent form, whether aquatic, terrestrial, etc.
D. the type of reproduction, whether bisexual, parthenogenetic, etc.
E. the presence or absence of pharyngeal grooves in the embryo.

23. (1.10) Which of the following is the outer germ layer or cell layer of an early embryo?

A. Ectoderm. B. Ectoplasm. C. Endoplasm.
D. Entoderm. E. Mesoderm.

24. (1.10) The human embryo receives its nourishment

A. in the form of yolk.
B. by diffusion from the mother's blood supply in its own independent blood system.
C. from the mother's blood which circulates through the embryo's vessels.
D. as a secretion from the uterine wall.
E. by manufacturing its own food

25. (1.10) A hermaphroditic animal usually reproduces by

A. self-fertilization. B. parthenogenesis.
C. cross-fertilization. D. asexual methods.
E. none of the above methods.

26. (1.10) Human sperms and eggs are similar in which one of the following respects?

A. They have the same number of chromosomes in their nuclei.
B. Their locomotion is achieved with equal facility.
C. They have the same relative amount of cytoplasm surrounding their nuclei.
D. About the same number of each is produced.
E. They have approximately the same aggregate mass of material in one cell.

27. (1.10) The epithelial tissue which constitutes the external body covering arises from the

A. endoderm. B. mesoderm. C. ectoderm.
D. chorion. E. amnion.

28. (1.10) The body of coelenterates is made up of two cell layers. These are

A. epidermis and submucosa.
B. ectoderm and endoderm.
C. ectoplasm and endoplasm.
D. cilia and pseudopodia.
E. protoplasm and cytoplasm.

29. (1.10) In mammals the embryo develops

A. in the ovary. B. in the umbilicus.
C. in the amniotic cavity. D. in the coelomic cavity.
E. in the mesenteries.

30. (1.10) Artificial parthenogenesis is ordinarily accomplished by the physical or chemical stimulation of

A. a zygote. B. a spermatozoan.
C. an unfertilized ovum. D. an unbranched hydra.
E. a fertilized egg.

31. (1.10) The ectoderm of the embryo gives rise to the

A. lining of the digestive tract. B. lungs.
C. liver. D. central nervous system.
E. blood vessels.

32. (1.10) The garter snake gives birth to living young. This species of snakes would be characterized as

A. viviparous. B. ovoviviparous. C. oviparous.
D. placental. D. precocial.

33. (1.10) A four-week old human embryo

A. is about two inches long.
B. has gill slits and a tail.
C. experiences its first heart-beat at this age.
D. has been called a fetus up to this stage.
E. has acquired distinct human form.

34. (1.10) In multicellular animals the term somatic is applied to all cells except the

A. male gametes. B. female gametes.
C. germ cells and their primordia of both sexes.
D. cells of the brain and nervous system.
E. cell comprising the auriculo-ventricular node in the heart.

35. (1.10) In the development of the apple from an apple blossom, the receptacle of the flower becomes the

A. stem of the apple. B. edible part of the apple.
C. core of the apple. D. seeds of the apple.
E. rough scales in the depression at the small end of the apple.

36. (1.10) Parthenogenesis occurs when an embryo develops from

A. a zygote. B. a zygospore.
C. an unfertilized egg. D. an antheridium.
E. a zoospore.

37. (1.10) A seed is most adequately described as a (an)

A. matured ovary. B. matured ovule.
C. egg which has undergone development.
D. zygote. E. fruit.

38. (1.10) In the case of the human menstrual cycle, ovulation with its characteristic symptoms occurs normally

A. concurrently with the onset of menstrual hemorrhage.
B. immediately after repair of the uterine tissues associated with the last menstrual period.
C. about halfway through the period of menstrual hemorrhage.
D. about halfway through the period between menstrual hemorrhages.
E. about five days before onset of menstrual hemorrhage.

39. (1.10) Food is supplied to the embryo of man by the

A. amnion. **B.** coelom. **C.** allantois.
D. pancreas. **E.** placenta.

40. (1.10) The type of reproduction most characteristic of land inhabiting vertebrates is

A. internal fertilization. **B.** budding.
C. external fertilization. **D.** binary fission.
E. none of the above.

41. (1.10) The union of a sperm and egg

A. restores the haploid number of chromosomes.
B. is known as insemination.
C. can only initiate cleavage.
D. gives rise to a zygote. **E.** is copulation.

42. (1.10) In human development the muscular, skeletal, vascular, reproductive, and excretory systems arise from the germ layer called the

A. gastrula. **B.** ectoderm. **C.** blastocoel.
D. blastula. **E.** mesoderm.

43. (1.10) Meiosis differs from mitosis in that

A. in meiosis one-half of each chromosome goes to each daughter cell.
B. meiosis goes on everywhere in the body where cells divide.
C. in meiosis, one member of each pair of chromosomes goes to each daughter cell.

44. (1.10) Of the following the part *not* included in the pistil is the

A. stigma. **B.** style. **C.** anther. **D.** ovule.
E. ovary.

45. (1.10) The fusion of two chromosomes in meiosis is called

A. synapse. **B.** synapsis. **C.** reduction division.
D. mitotic division. **E.** telophase.

46. (1.10) One of the following is *not* a phase of mitosis.

A. prophase. **B.** mesophase. **C.** metaphase.
D. anaphase. **E.** telophase.

47. (1.10) An organ of nourishment common to mother and baby is the

A. blastula. **B.** placenta. **C.** uterus.
D. notochord. **E.** blood.

48. (1.10) An embryonic membrane:

A. gastrula. **B.** amnion. **C.** holoblastic.
D. archenteron. **E.** blastocoele.

49. (1.10) A hollow ball stage in embryo development:

A. blastula. **B.** gastrula. **C.** morula.
D. endoderm. **E.** mesoderm.

50. (1.10) The outer layer of embryonic tissue:

A. mesoderm. **B.** endoderm. **C.** ectoderm.
D. archenteron. **E.** blastocoele.

Items 51 - 57: True or False

51. (1.10) Centrosome is the name applied to the substance of which chromosomes are composed.

52. (1.10) Endoderm is the outermost of the three germ layers of triploblastic organisms.

53. (1.10) The oviduct leading from ovary to uterus is also called the Fallopian tube.

54. (1.10) Isogamy is a state (concerning reproduction) in which the gametes are different.

55. (1.10) Haploid is a term used when only a single set of chromosomes are present, as in gametes.

56. (1.10) Embryonic fishes possess an amnion.

57. (1.10) Germplasm loses its continuity during cell division.

58. (1.10) Which of the following is not a "true" extra-embryonic membrane?

A. Chorion. **B.** Placenta. **C.** Amnion.
D. Allantois. **E.** All of these.

59. (1.10) Which of the following terms are foreign to meiosis?

A. Polar bodies. **B.** Dyads. **C.** Monads.
D. Tetrads. **E.** None of these.

60. (1.10) Which of the following is the first to break the proper sequence?

A. Interphase. **B.** Prophase. **C.** Anaphase.
D. Metaphase. **E.** Telophase.

Items 61 - 64: True or False

61. (1.10) A sperm cell is in the haploid state as it has the (n) number of chromosomes.

62. (1.10) The spermatagonium (premordial germ cell) of man has 24 chromosomes.

63. (1.10) Two eggs fertilized at exactly the same time give rise to identical twins.

64. (1.10) In birds and reptiles, the allantois serves as a temporary excretory and respiratory organ until the animal develops permanent structures to perform these functions.

65. (1.10) Which of the following is the first to break the proper sequence?

A. Ovary. **B.** Oviduct. **C.** Vagina.
D. Uterus. **E.** None of these.

66. (1.10) Which of the following is the first to break the proper sequence?

A. Testis. **B.** Inguinal canal. **C.** Seminal vesicle.
D. Urethra. **E.** None of these.

67. Which of the following is the first to break the proper
(1.10) sequence?

A. Fertilized egg.
B. Gastrula.
C. Blastula.
D. Foetus.
E. Infant.

68. Which of the following is the first to break the proper
(1.10) sequence?

A. Spore mother cell.
B. Spore.
C. Gametophyte.
D. Sporophyte.
E. Gamete.

69. The phase of mitosis during which chromosomes are
(1.10) arranged on the equatorial plate of the cell:

A. prophase.
B. metaphase.
C. anaphase.
D. telophase.
E. none of these.

70. Series of divisions resulting in maturation of the gametes:
(1.10)

A. Meiosis.
B. Myopia.
C. Mitosis.
D. Psychosis.
E. Amitosis.

71. Parthenogenesis is
(1.10)

A. the presence of both sexes in the same individual.
B. spontaneous generation.
C. the development of unfertilized eggs.
D. budding.
E. the process by which mutations occur.

72. Exact similarity between chromosomes of the various
(1.10) cells within the same tissue of a plant or an animal is largely due to the mechanism of

A. segregation.
B. meiosis.
C. mitosis
D. fertilization.
E. maturation.

Item 73 deleted.

74. The two-layered embryonic stage in the development
(1.10) of the higher animals is called the

A. blastula.
B. foetus.
C. zygote.
D. ovule.
E. nucleole.

75. The embryos of land vertebrates are surrounded by a
(1.10) sac of watery fluid known as the

A. chorion.
B. allantois.
C. placenta
D. amnion.
E. aqueous membrane.

76. Pollen is produced in the
(1.10)

A. anther.
B. filament.
C. stigma.
D. style.
E. ovary.

77. A fertilized egg cell is the product of the fusion of
(1.10)

A. a gamete and a zygote.
B. two zygotes.
C. two gametes.
D. two gonads.
E. one gonad and an ovum.

78. The period of time in days between the last occurring
(1.10) menses and birth in the human is normally very close to

A. 292.
B. 280.
C. 270.
D. 261.
E. 252.

79. The uterine placenta in humans
(1.10)

A. serves as an organ of nutrition, respiration, and excretion for the developing embryo.
B. is a sac containing the fluid in which the developing embryo is suspended.
C. produces a hormone which helps to maintain pregnancy.
D. is a sac which absorbs and stores all embryonic waste products until birth occurs. Another name for it is the allantois.
E. is the cord attached to the umbilicus of the embryo.

80. Hermaphroditism is the term given to the condition in
(1.10) which the organism

A. has secondary sexual characteristics common normally to the opposite sex.
B. has been unsexed.
C. has both male and female reproductive organs.
D. produces young from unfertilized eggs.
E. develops with one part of the body female and the other part male.

81. Parthenogenesis is the condition in which the organism
(1.10)

A. has both male and female reproductive organs.
B. develops from an unfertilized egg.
C. is believed to arise spontaneously from inorganic matter.
D. develops normally from a fertilized egg.
E. develops with one part of the body female and the other part male.

Item 82 deleted.

83. The immature plant found in a seed is called
(1.10)

A. epicotyl.
B. endosperm.
C. sporling.
D. perisperm.
E. embryo.

84. The process of double fertilization commonly occurs in
(1.10)

A. gymnosperms.
B. angiosperms.
C. bryophytes.
D. ferns (Filicineae).
E. cycads.

85. The gills of mushrooms are
(1.10)

A. specialized layers bearing basidia.
B. organs of respiration.
C. specialized layers producing poisons.
D. photosynthetic tissues.
E. sex organs.

86. Which of these animals is not hermaphroditic?
(1.10)

A. Tapeworm.
B. Planaria.
C. Earthworm.
D. Crayfish.

Items 87 - 96. A chromosome which is made up of a single chromatid may be called a monad; of two chromatids, a dyad; of three chromotids, a triad; of four chromatids, a tetrad.

A. Monad.
B. Dyad.
C. Triad.
D. Tetrad.

In which of the above forms would the chromosomes be found in the following stages?

87. First polar body.
(1.10)

88. Mature ovum.
(1.10)

89. Mature sperm.
(1.10)

90. Metaphase of the first cleavage division.
(1.10)

91. Metaphase of the first maturation division in female.
(1.10)

92. Metaphase of the first maturation division in male.
(1.10)

93. Metaphase of second cleavage division.
(1.10)

94. Metaphase of the second maturation division in female.
(1.10)

95. Metaphase of the second maturation division in male
(1.10)

96. Second polar body.
(1.10)

97. How is the third cleavage plane of the frog egg related
(1.10) to the previous cleavage planes?

A. Parallel to the first.
B. Parallel to the second.
C. Parallel to the first and second.
D. At right angle to the first and second.
E. At right angle to first only.

Items 98 - 102. To which of the listed stages of spermatogenesis do the following stages of oögenesis correspond?

Listed states of spermatogenesis:

A. First spermatocyte.
B. Second spermatocyte.
C. Sperm.
D. Spermatogonium.

98. First oöcyte.
(1.10)

99. Second oöcyte.
(1.10)

100. First polar body.
(1.10)

101. Second polar body.
(1.10)

102. Ovum.
(1.10)

103. The frog's egg is considered
(1.10)

A. a homolecithal egg.
B. telolecithal egg.
C. centrolecithal egg.
D. a polylecithal egg.

Items 104 - 113.

A. ectoderm only.
B. ectoderm and mesoderm.
C. endoderm only.
D. endoderm and mesoderm.
E. mesoderm only.

From which of the above does each of the following originate?

104. Epithelial cells lining the bladder.
(1.10)

105. Functional cells of the skin glands.
(1.10)

106. Peritoneum.
(1.10)

107. Red blood cells.
(1.10)

108. Retina.
(1.10)

109. Skin.
(1.10)

110. Small intestine.
(1.10)

111. Stomach.
(1.10)

112. Teeth.
(1.10)

113. White blood cells.
(1.10)

Items 114 - 123 deleted.

124. Synapsis occurs in the
(1.10)

A. spermatogonia.
B. first spermatocyte.
C. second spermatocyte.
D. spermatid.

125. Which of the following is a chromatic nucleolus?
(1.10)

A. Karysome.
B. Plasmosome.
C. Mitosome.
D. Chondriosome.

126. Estrogen is produced by the
(1.10)

A. egg.
B. uterus.
C. pituitary gland.
D. corpus luteum.
E. follicle.

127. The somatopleure is made up of
(1.10)

A. a layer of ectoderm and a layer of endoderm.
B. a layer of ectoderm and a layer of mesoderm.
C. a layer of endoderm and a layer of mesoderm.
D. two layers of mesoderm.

128. The process of double fertilization commonly occurs in
(1.10)

A. gymnosperms.
B. angiosperms.
C. bryophytes.
D. ferns (Filicineae).
E. cycads.

Questions 129 - 132.

A. Autogamy.
B. Conjugation.
C. Endomixis.
D. Longitudinal binary fission.
E. Transverse binary fission.

Which of the above occur in Paramecium, and may be described by the brief phrase below?

129. Asexual reproduction.
(1.10)

130. Cross fertilization. **131.** Parthenogenesis.
(1.10) (1.10)

132. Self-fertilization.
(1.10)

133. What is the name of the external opening of the blastula?
(1.10)

A. Neuropore. **B.** Mouth. **C.** Archenteron.
D. Blastopore. **E.** It has no such opening.

Items 134 - 136. Protozoa reproduce asexually by

A. unoriented binary fission.
B. transverse binary fission.
C. longitudinal binary fission.
D. multiple fission. **E.** budding.

In which of the above ways do the following reproduce?

134. Amoeba. **135.** Paramecium. **136.** Malarial parasite.
(1.10) (1.10) (1.10)

Items 137 - 146. Note: the three germ layers are called

A. Mesoderm. **B.** Ectoderm. **C.** Endoderm.

From which of the three germ layers do each of the following structures originate?

137. Lens of eye. **138.** Liver.
(1.10) (1.10)

139. Lungs. **140.** Muscular layers of stomach.
(1.10) (1.10)

141. Pancreas. **142.** Epidermis.
(1.10) (1.10)

143. Epithelial lining of the mouth.
(1.10)

144. Epithelial lining of the small intestine.
(1.10)

145. Epithelial lining of the stomach. **146.** Kidneys.
(1.10) (1.10)

147. What eventually becomes of the cleavage cavity? It
(1.10) forms the

A. coelom. **B.** digestive tract. **C.** body cavity.
D. archenteron. **E.** It disappears.

148. The volume of the human ovum is
(1.10)

A. 350, **B.** 3,500, **C.** 35,000,
D. 350,000 times the volume of a human sperm.

149. Where does fertilization occur in the life cycle of the
(1.10) malarial parasite?

A. In stagnant water. **B.** In human blood.
C. In the stomach of a mosquito.
D. Fertilization does not occur.

Items 150 - 159. The fertilized egg of a certain species has eight chromosomes.

A. Two. **B.** Four. **C.** Eight. **D.** Sixteen.
E. Thirty-two.

How many chromosomes are there in each cell at the following stages?

150. Blastula. **151.** First polar body.
(1.10) (1.10)

152. Four-celled stage. **153.** Gastrula.
(1.10) (1.10)

154. Mature ovum. **155.** Mature sperm.
(1.10) (1.10)

156. Metaphase first maturation division.
(1.10)

157. Metaphase second maturation division.
(1.10)

158. Second polar body. **159.** Two-celled stage.
(1.10) (1.10)

160. What is the most important part of conjugation in
(1.10) Paramecium?

A. Exchange of macronuclei.
B. Temporary fusion of two individuals.
C. Distintegration of macronuclei and micronuclei.
D. Formation of a fertilization nucleus which gives rise to new macro- and micronuclei.

161. The yolk materials of the egg vertebrate
(1.10)

A. are the first enzymes to become active in the embryonic cells.
B. are the proteins incorporated in the blood plasma and extra-cellular tissue matrix of the embryo.
C. are hydrolyzed to yield small molecules which are used in both anabolic and catabolic processes.
D. preserve the aqueous medium in which the embryo develops.
E. afford mechanical protection against injury to the developing embryo.

162. The earliest step in the development of an amphibian
(1.10) zygote is

A. a series of mitotic cell divisions.
B. mass migrations of cells. **C.** increase in cell size.
D. the formation of a hollow ball.
E. entry of a sperm into the egg.

163. During the development of the frog, what becomes of
(1.10) the blastopore?

A. It becomes the mouth. **B.** It becomes the anus.
C. It becomes the archenteron. **D.** It becomes closed.

164. In the amphibian, cleavage eventually results in a hollow
(1.10) sphere whose cavity

A. becomes the alimentary canal.
B. becomes the coelom.
C. becomes enclosed in blood vessels and heart.
D. becomes the cavity in the neural tube.
E. disappears in later embryonic stages.

165. During gastrulation, the presumptive ectoderm
(1.10)

A. changes its relative position from the inside of the embryo to the outside.
B. changes its relative position from the outside of the embryo to the inside.
C. divides more rapidly than before gastrulation.
D. spreads out to enclose the whole embryo.
E. is unaltered.

166. (1.10) The cells produced by mitotic divisions in the developing amphibian first shift their positions en masse relative to each other

A. in the first cleavage. **B.** in the late cleavages.
C. during gastrulation.
D. immediately after gastrulation.
E. when the embryo utilizes energy-rich food substances not present in the fertilized egg.

167. (1.10) Amphibian eggs partially compressed by glass plates during early cleavage most frequently give rise to

A. a piece corresponding only to the dorsal part of a normal embryo.
B. a piece corresponding only to the ventral part of a normal embryo.
C. two normal, half-sized embryos.
D. (a) two normal, half-sized embryos, or (b) one small normal embryo and a dorsal "piece," with equal frequency.
E. a normal embryo.

168. (1.10) In amphibian eggs partially compressed between glass plates, the first three cleavage planes are such that

A. all are parallel to each other.
B. each is at right angles to both of the others.
C. all pass through both animal and vegetal hemispheres.
D. all are equatorial.
E. the first passes through animal and vegetal poles, the second and third are parallel to the equator.

169. (1.10) In amphibians, the first three cleavages

A. proceed rhythmically, all cells dividing simultaneously, in a fixed spatial pattern.
B. proceed more rapidly at the vegetative pole than at the animal pole.
C. occur at random temporally but with a fixed spatial pattern.
D. occur at random spatially but with a fixed temporal pattern.
E. occur at random spatially and temporally.

170. (1.10) In cleavage, with each successive division

A. the number of chromosomes per cell is reduced.
B. the number of chromosomes per cell is increased.
C. the volume of cytoplasm per cell is reduced.
D. the volume of cytoplasm per cell is increased.
E. none of the foregoing is true.

171. (1.10) The normal stimulus to embryonic development in a mature egg is

A. extrusion of a polar body.
B. one of the anterior pituitary hormones.
C. cooling incident to leaving the reproductive tract.
D. fertilization.
E. the acidity of the uterine secretions.

172. (1.10) Spemann's experimental procedure consisted of constricting an egg immediately after fertilization and

A. allowing the half without a nucleus to develop.
B. inducing cleavage first in one half and then in the other.
C. dividing the eggs into two groups, depending on whether the constriction was frontal or median.
D. putting into the half without a nucleus a small segment of tissue which had been removed from the zygote nucleus by a micropipette.
E. permitting a descendant of the zygote nucleus to pass into the half without a nucleus.

173. (1.10) In fission of Paramecium when does the duplication of the contractile vacuoles occur?

A. After division of the macronucleus.
B. Just before constriction into two cells.
C. After duplication of the cilia.
D. Before any other visible signs of division.

174. (1.10) Pollination is

A. growth of the pollen tube through the style to the ovary.
B. union of a nucleus of the pollen tube with the nucleus of the egg.
C. transfer of pollen to the stigma.
D. germination of the pollen grain.
E. production of mature pollen by the anther.

175. (1.10) After ovulation in mammals, the ruptured follicle

A. disappears, all its cells disintegrating.
B. passes as waste material down the oviduct with the egg.
C. mends itself and begins the maturation of another egg.
D. becomes a part of the epithelial covering of the ovary.
E. differentiates into a temporary endocrine gland.

176. (1.10) In animals

A. the coelom is contained within the enteron.
B. the enteron may usually be correlated with the triploblastic condition.
C. the coelenteron is considered to be a more complex structure than a separate coelom and enteron.
D. only man has a coelenteron.
E. the canal opening of the coelenteron is much larger than the mouth opening.

177. (1.10) Cell cleavage is the process by which

A. the egg is able to reduce its surface.
B. a male reproductive cell fertilizes the egg.
C. the egg divides into many small cells.
D. cytoplasmic division but not nuclear division occurs.
E. the egg reduces its cell number to one half.

Items 178 - 185 are based on the key list below.

KEY

A. Megaspore.
B. Spore mother cell.
C. Fruit.
D. Seed.
E. Microspore.
F. Mature pollen grain.
G. Sperm.
H. Egg.
I. Primary endosperm nucleus.
J. Zygote.

178. (1.10) Which of the above gives rise to an embryo?

1. H. 2. G. 3. F. 4. J. 5. I.

179. (1.10) Which structure develops from a matured ovary?

1. D. 2. J. 3. C. 4. B. 5. E.

180. (1.10) In which of the following is the nucleus diploid?

1. E. **2.** J. **3.** I. **4.** F. **5.** G.

181. (1.10) Prior to fertilization which cell constitutes a part of the mature female gametophyte?

1. J. **2.** I. **3.** H. **4.** E. **5.** F.

182. (1.10) After fertilization, into what will the ovule develop?

1. J. **2.** C. **3.** D. **4.** I. **5.** H.

183. (1.10) In which of the above are the sperms produced?

1. F. **2.** E. **3.** I. **4.** C. **5.** A.

184. (1.10) What cell in an anther produces a microspore?

1. F. **2.** G. **3.** B. **4.** E. **5.** A.

185. (1.10) Which of the above gives rise to a female gametophyte?

1. J. **2.** H. **3.** A. **4.** B. **5.** D.

Items 186 - 190. From the key list below, select the term to which each of the items most clearly refers.

KEY

A. Biogenesis. **B.** Estrus. **C.** Implantation.
D. Ovulation. **E.** Menstruation.

186. (1.10) Period of sexual receptivity in the lower mammals.

187. (1.10) Termination of a periodic sexual cycle, with displacement of the lining of the uterus.

188. (1.10) Eruption of the egg from the follicle.

189. (1.10) The concept of the continuity of life.

190. (1.10) An event immediately preceding the release of the egg from the ovarian follicle.

Items 191 - 197. The terms in the following key list apply to the development of an embryo. Use them to answer the following items.

KEY

A. Gastrula. **B.** Archenteron. **C.** Blastopore.
D. Coelom. **E.** Blastula.

191. (1.20) With the appearance of which of the above stages are the first two germ layers of the embryo associated?

192. (1.10) Invagination of which stage results in a gastrula?

193. (1.10) The blastopore appears in which stage?

194. (1.10) Which of the choices in the key list develops *last?*

195. (1.10) Which is a stage previous to formation of germ layers?

196. (1.10) Which is the forerunner of the intestine in vertebrates?

197. (1.10) In amphioxus the spaces in the pockets of mesoderm produce which?

198. (1.20) A feature of meiosis not found in mitosis is that

- **A.** the chromosomes split lengthwise before the cell divides.
- **B.** the chromatin of the nucleus condenses into visible chromosomes.
- **C.** the chromosomes coming from the father are separated into one cell, those from the mother into another cell.
- **D.** the division of the cytoplasm is quantitatively unequal.
- **E.** each chromosome which came from the father pairs with the corresponding chromosome which came from the mother.

199. (1.20) In comparing human eggs and sperms it is *inaccurate* to state that

- **A.** the egg contributes more toward determining the characteristics of the new individual.
- **B.** the sperm alone determines the sex of the new individual.
- **C.** more sperms than eggs are produced with subsequent greater mortality among sperms than eggs.
- **D.** the egg carries more food than the sperm for nourishing the embryo until connection with the placenta is established.
- **E.** the sperm has powers of locomotion and the egg does not.

200. (1.20) At birth, the female baby has in her body

- **A.** billions of germ cells from which eggs will develop.
- **B.** about five hundred germ cells from which eggs will develop.
- **C.** tiny clusters of rudimentary eggs in two ovaries.
- **D.** embryonic tissue from which egg cells will develop.
- **E.** genes which will cause reproductive cells to originate and mature.

201. (1.20) The cells of a fern gametophyte possess half as many chromosomes as the cells of the sporophyte.

- **A.** The sporophyte is the conspicuous generation in ferns and flowering plants.
- **B.** Meiosis occurs during the production of spores from which the gametophyte develops.
- **C.** The fern gametophyte possesses both male and female sex organs.
- **D.** Mitosis occurs during the gametophyte generation, but not during the sporophyte generation.
- **E.** The male and female gametophytes of flowering plants are much less complex than the gametophytes of ferns.

202. (1.20) When a female chimpanzee gives birth to her first offspring, she is likely to

- **A.** know instinctively at least the essentials of chimpanzee infant care.
- **B.** give indications of satisfaction.
- **C.** pay little attention to it. **D.** examine it.
- **E.** attack it if hungry.

203. (1.20) When the seed of a flowering plant germinates,

- **A.** the development of the gametophyte is resumed.
- **B.** a zygote is produced.
- **C.** the development of the sporophyte is begun.
- **D.** the development of the sporophyte is resumed.
- **E.** fertilization occurs.

204. A zygote is implanted in the wall of the uterus
(1.20)

A. before cell division has begun.
B. while still in the form of a solid mass of cells.
C. very soon after developing a trophoblast.
D. just before the yolk sac disappears.

For items 205 and 206 mark the pairs of occurrences according to the key.

KEY

1. An increase in **A** will be accompanied by an increase in **B.**
2. An increase in **A** will be accompanied by a decrease in **B.**
3. A change in **A** will produce no change in the size or rate of functioning in **B.**

205. **A.** Secretion of estrin (estrogen) by ovarian follicle.
(1.20) **B.** Thickness of the uterine lining.

206. **A.** Time elapsing between conception and birth.
(1.20) **B.** Size of the uterus.

Items 207 - 209 are based upon the following key:

KEY

A. Hermaphroditism. **B.** Parthenogenesis.
C. Biogenesis. **D.** Maturation. **E.** Mitosis.

207. Eggs laid by a queen bee may hatch into more queen
(1.20) bees, workers, or drones.

208. The size and number of potatoes produced by a potato
(1.20) plant depends upon the rate at which the plant carries on photosynthesis.

209. The choice of a mate is presumably less difficult for an
(1.20) earthworm than for a honey bee.

210. It is *impossible* for a mother to affect her unborn child
(1.20) by

A. the child's inheritance of a blood factor in conflict with her own.
B. her use of tobacco or alcohol.
C. her addiction to morphine.
D. an intense desire that the child be a male.
E. all of the above four.

Items 211 - 221.

After the number on the answer sheet corresponding to each blank in the following paragraphs, blacken the one lettered space which designates the word or phrase which should fill the blank. Choose the word or phrase from the list below the paragraph.

In mammals, including man, female gametes are produced in a special organ called 211. At regular intervals, a group of 212 develop, but normally only one matures to form 213 which enters 214 after ovulation has occurred. If fertilization then takes place, the zygote passes into 215 whose lining is especially prepared to nourish and protect the developing embryo.

A. An egg mother cell or egg mother cells.
B. An ovary or ovaries. C. The uterus.
D. An oviduct. E. A follicle or follicles.

At the beginning of the menstrual cycle, the pituitary secretes 216 which stimulates active cell division in the germinal epithelium of the ovary. The resulting cells secrete a hormone, 217, which stimulates changes in the lining of the organ referred to at the close of the preceding paragraph. After ovulation, a second hormone from the pituitary **218**, stimulates the production of the yellow body. This body secretes **219**, a hormone which maintains the lining referred to above and stimulates the glands to begin functioning. During this cycle, the hormone **220** also inhibits the pituitary from further production of **221** but if fertilization does not occur secretion of the *latter* starts a new cycle. (All of the above items are classified as 1.20)

A. Estrogen. **B.** Progestin.
C. Luteinizing hormone.
D. Follicle stimulating hormones.

222. An egg passing to the exterior of the body of *homo*
(1.20) *sapiens* passes in succession from the ovary to the

A. uterus, to the oviduct, to the cervix, to the vagina.
B. oviduct, to the vagina, to the cervix, to the uterus.
C. oviduct, to the cervix, to the uterus, to the vagina.
D. oviduct, to the uterus, to the cervix, to the vagina.
E. cervix, to the uterus, to the oviduct, to the vagina.

223. A sperm cell on its way to the exterior of the body of
(1.20) man passes from the testis to the

A. sperm duct, to the epididymis, to the point of union of the tube from the seminal vesicle, to the urethra.
B. epididymis, to the urethra, to the point of union of the tube from the seminal vesicle, to the sperm duct.
C. urethra, to the point of union of the tube from the seminal vesicle, to the epididymis, to the sperm duct.
D. epididymis, to the point of union of the tube from the seminal vesicle, to the sperm duct, to the urethra.
E. epididymis, to the sperm duct, to the point of union of the tube from the seminal vesicle, to the urethra.

224. In the cycle of mitosis from one resting cell stage to the
(1.20) next one, which of the following does not occur?

A. Longitudinal division of chromosomes.
B. Duplication of genes. **C.** Spindle formation.
D. Increase in number of cells.
E. Reduction-division.

225. Fertilization of the mammalian egg and implantation
(1.20) induce subsequent development and very active functioning over a long period of time of the

A. islets of Langerhans. **B.** epididymis.
C. corpus luteum. **D.** prostate gland.
E. organ of Corti.

226. Generally speaking, eggs with very little yolk are usually
(1.20) associated with

A. external fertilization as it occurs in fishes.
B. hermaphroditism (where both eggs and sperms are produced by the same individual animal).
C. external fertilization as it occurs in frogs.
D. parthenogenesis (unfertilized eggs giving rise to embryos).
E. internal fertilization.

227. Which of the following is *not* achieved by plant hy-
(1.20) bridization?

A. Progeny which all breed true to the hybrid phenotype.
B. Larger fruit.
C. Greater variability in the progeny.
D. Increased vigor and resistance to disease.
E. Greater number of progeny.

228. (1.20) Which one of the following would constitute an application of the progeny test?

A. The offspring (progeny) of certain dog crosses are checked periodically from birth to adulthood to observe the order of appearance of inherited traits.
B. An orchardist cross-pollinates Jonathan and Baldwin apple blossoms in an attempt to obtain an apple combining some of the good qualities of both these varieties.
C. A rabbit breeder back-crosses some of the young with their heterozyous parents to determine which of the young are homozygous for a given trait.
D. The desirable traits of a young race horse are compared with those traits known to have been characteristic of the horse's ancestors listed in its pedigree.
E. All weaklings from the progeny of a certain poultry cross are culled out and only the best are used for subsequent breeding purposes.

229. (1.20) After the pollen grain containing the sperm cell has been formed on a corn tassel and transferred to the end of the silk on the developing ear

A. it swims down the tube in the silk to fertilize the egg cell.
B. it germinates a tube which pushes down into the silk.
C. nothing can happen until a pollinating agent such as the wind or an insect functions.
D. it decomposes because its work is accomplished.
E. it is transferred to the egg by curling and bending of the long silk.

230. (1.20) The greatest possible number of zygotes that could result from the fertilization of the ova arising from one primary oocyte by the spermatozoa arising from one primary spermatocyte would be

A. one. **B.** two. **C.** four. **D.** eight.
E. four hundred.

231. (1.20) One primordial female germ cell will, upon maturation, give rise to

A. one ovum. **B.** two ova. **C.** four ova.
D. 300 to 400 ova.

232. (1.20) One primordial male germ cell will, upon maturation, give rise to

A. one spermatozoan. **B.** four spermatozoa.
C. about 100 spermatozoa.
D. over 200,000,000 spermatozoa.

233. (1.20) The greatest number of zygotes which could possibly arise from the union of all the ova from one primordial female germ cell with all the spermatozoa from one primordial male germ cell would be

A. one. **B.** two. **C.** four. **D.** eight.
E. 600 to 800.

234. (1.20) Reproductive cells in normal human beings are produced

A. in greater numbers by the female than the male.
B. for a longer period in the female than in the male.
C. in equal numbers by both sexes.
D. by the gonads from birth to death.
E. in larger numbers for a longer period of time in the male.

235. (1.20) In a case of multiple human birth where eggs are separately fertilized, the offspring are

A. always of the same sex.
B. always of both sexes.
C. no more alike than ordinary brothers and sisters.
D. identical in all their characteristics.
E. attached to one placenta.

236. (1.20) Which of the following pairs are homologous structures?

A. The wings of a butterfly and the wings of a bluebird.
B. The flippers of a whale and the front legs of a dog.
C. The lower pair of fins of a fish and the legs of a man.

237. (1.20) The body cells of a plant or animal producing gametes with 14 chromosomes will contain

A. one-fourth as many chromosomes.
B. one-half as many chromosomes.
C. the same number of chromosomes.
D. twice as many chromosomes.
E. four times as many chromosomes.

238. (1.20) Which one of the following constitutes the best reason as to why the fish can be distinguished at an early stage from the human embryo, whereas the pig cannot be distinguished until a later stage?

A. The fish shows adaptation for living in water.
B. Fish are widely removed from man, whereas the pig and man have a more recent common ancestor.
C. The fish has no limbs for land locomotion.
D. Fish are in the class Pisces, whereas the pig is in the class Mammalia.
E. Fish develop scales, fins and laterally placed eyes, whereas the pig develops skin, limbs, and more nearly frontal eyes like man.

239 - 243. In each series of words, select the term that does not belong to the group.

239. (1.20) **A.** Mitosis. **B.** Meiosis. **C.** Reproduction. **D.** Anaphase. **E.** Digestion.

240. (1.20) **A.** Uterus. **B.** Placenta. **C.** Vagina. **D.** Vas deferens. **E.** Ovary.

241. (1.20) **A.** Penis. **B.** Testis. **C.** Oviduct. **D.** Sperm. **E.** Prostate.

242. (1.20) **A.** Follicle. **B.** Ovulation. **C.** Ovary. **D.** Spermatogenesis. **E.** Ovum.

243. (1.20) **A.** Syphilis. **B.** Cancer. **C.** Gonorrhea. **D.** Pneumonia. **E.** Tuberculosis.

244. (1.20) In the following pair, blacken space 1 if the first element of the pair is definitely greater than the second; space 2 if the second is definitely greater than the first; and space 3 if the two are approximately equal.

A. Germ layers in a mature frog.
B. Germ layers in a mature blastula.

245. (1.20) In the following pair, blacken space 1 if the first element of the pair, is definitely greater than the second; space 2 if the second is definitely greater than the first; and space 3 if the two are approximately equal.

A. Number of mature sex cells in a woman.
B. Number of mature sex cells in a man.

246. (1.20) In the following pair, blacken space 1 if the first element of the pair is definitely greater than the second; space 2 if the second is definitely greater than the first; and space 3 if the two are approximately equal.

- **A.** Number of gonads in a man.
- **B.** Number of gonads in a woman.

For items 247 - 249 use the following key.

KEY

- **A.** True of amphibians and mammals.
- **B.** True of amphibians but not mammals.
- **C.** True of mammals but not amphibians.
- **D.** Not true of either mammals or amphibians.

247. (1.20) Ureters conduct urine directly into the urinary bladder.

248. (1.20) Sperm cells might occasionally be present in the urine of the male.

249. (1.20) Ova are discharged from the ovary into the body cavity before entering the oviducts.

250. (1.20) In the human species, the stimulus to mate is initiated primarily by the

- **A.** autonomic nervous system.
- **B.** hormones parathormone and estrogen and associated physical factors.
- **C.** cerebellum.
- **D.** hormones theelin and testosterone and psychological factors.
- **E.** hormone adrenalin and the physiological effects it normally induces.

251. (1.20) All except which one of the following parts are directly involved in production in flowering plants?

A. Stigma. **B.** Sepal. **C.** Pollen tube.
D. Style. **E.** Stamen.

252. (1.20) In the following pair, blacken space 1 if the first element of the pair is definitely greater than the second; space 2 if the second is definitely greater than the first; and space 3 if the two are approximately equal.

- **A.** Effectiveness of spores as agents for distribution of a species.
- **B.** Effectiveness of gametes as agents for distribution of a species.

253. (1.20) In the following pair, blacken space 1 if the first element of the pair is definitely greater than the second; space 2 if the second is definitely greater than the first; and space 3 if the two are approximately equal.

- **A.** Number of erythrocytes that pass during one month from the blood stream of the mother into that of the embryo in utero.
- **B.** Number of erythrocytes that pass during one month into the blood stream of the mother from that of the embryo in utero.

For each of the items 254 - 262 mark

- **A.** if the statement refers to asexual reproduction only.
- **B.** if the statement refers to sexual reproduction only.
- **C.** if the statement refers to both.
- **D.** if the statement refers to neither.

254. (1.20) Involves the formation of spores in plants.

255. (1.20) Involves the fusion of like gametes.

256. (1.20) Involves the fertilization of an egg.

257 (1.20) Involves, in animals, a process which results in doubling the number of chromosomes found in each cell involved.

258. (1.20) Involves, in plants, a process which results in doubling the number of chromosomes found in the preceding generation.

259. (1.20) Involves the process of mitotic cell division.

260. (1.20) Always increases the number of individuals in the species.

261. (1.20) Makes possible an assortment and regrouping of genetic factors in the new generation.

262. (1.20) Does not require two individuals.

263. (1.20) If hereditary traits were transmitted through the cytoplasm rather than the nucleus, offspring would most resemble

A. the father. **B.** the mother. **C.** each other.
D. we cannot tell without additional data.

264. (1.20) The greatest value of sexual reproduction as compared with asexual is

- **A.** a greater uniformity of offspring.
- **B.** greater variability among offspring.
- **C.** a lower mortality among offspring.
- **D.** that the offspring are more like their parents.

265. (1.20) All except which one of the following are parts of reproductive organs in flowering plants?

A. Stigma. **B.** Corolla. **C.** Pollen tube.
D. Style. **E.** Stamen.

266. (1.20) In addition to zygote production, what is the consequence of double fertilization in flowering plants?

- **A.** Increased vigor in the progeny.
- **B.** A reserve food supply for the embryo.
- **C.** Multiplication of heritable trait combinations.
- **D.** Polyploids, such as double petunias (with twice the normal number of petals).
- **E.** None. Double fertilization has no real significance.

267. (1.20) In human reproduction the normal sequence is

- **A.** production of an egg, passage of egg into body cavity, fertilization in the uterus, implantation in the vaginal wall, development, birth.
- **B.** production of an egg, passage of egg through oviduct, implantation in the uterine wall, fertilization, development, birth.
- **C.** production of an egg, ovulation, fertilization in the ovary, implantation in the uterine wall, development, birth.
- **D.** production of an egg, ovulation, fertilization in the oviduct, implantation in the uterine wall, development, birth.
- **E.** None of the above.

268. (1.20) Which of the following is always true in connection with sexual reproduction in animals?

A. Fertilization takes place in liquid surroundings.
B. The mates come at least within visible distance of each other.
C. The gametes, once released, are on their own.
D. Sperms and eggs are produced in the bodies of different individuals.
E. A complete sperm and a complete egg cell must unite to produce a new individual.

269. (1.20) In placental animals,

A. the mother's blood circulates freely by way of the umbilical cord through the blood vessels of the fetus.
B. the eggs are minute, possess very little yolk, and are retained within the mother's body for development.
C. only one offspring can develop in one gestation period.
D. the eggs, which contain much yolk, develop into young within the oviducts of the mother's body.
E. the young are born in a premature state and must undergo further development within a pouch (marsupium) where they are nourished and protected until they can run about and find their own food.

270. (1.20) If a fertile chicken egg were covered with plaster of Paris, then incubated, it would probably not hatch because (select the most complete answer).

A. the shell would become impervious to moisture.
B. excretion would be impossible.
C. respiration would cease.
D. escape of the chick would be impossible.
E. All of the above would play a role in arresting development.

271. (1.20) Failure of implantation to take place may be due to

A. malfunctioning of the follicle in producing its hormone.
B. use of blood types which are incompatible.
C. failure to match tissues properly.
D. non-occurrence of menstruation at the normal period.
E. soil which is too highly acid.

272. (1.20) In the case of the human menstrual cycle, ovulation with its characteristic symptoms occurs normally

A. concurrently with the onset of menstrual hemorrhage.
B. immediately after repair of the uterine tissues associated with the last menstrual period.
C. about halfway through the period of menstrual hemorrhage.
D. about halfway through the period between menstrual hemorrhages.
E. about five days before onset of menstrual hemorrhage.

273. (1.20) In living tissues of an embryo cultured artificially it is possible to distinguish, with the naked eye, heart muscle from diaphragm muscle because

A. the muscle tissue from the diaphragm is striated.
B. the muscle tissue from the diaphragm is made up of spindle-shaped fibers.
C. the cells making up diaphragm muscle tissue are nucleated.
D. the heart muscle tissue is striated.
E. the heart muscle tissue is self-activating.

274. (1.20) Production of seedless or parthenocarpic tomato fruits can readily be induced by

A. removing the ovules.
B. not allowing pollination to occur.
C. killing the pollen grains.
D. applying auxin to the pistil.
E. removing the anthers.

275. (1.20) The complex reproductive system of the earthworm is most useful in promoting

A. cross fertilization.
B. high rate of egg production.
C. internal fertilization.
D. self fertilization.
E. societal organization among populations of earthworms.

Items 276 - 285. There are five stages in the history of a cell in relation to mitosis.

A. Prophase.
B. Metaphase.
C. Anaphase.
D. Telophase.
E. Interphase or resting stage.

In which stage does each of the following occur?

276. (1.20) Chromatin becomes condensed into chromosomes.

277. (1.20) Chromosomes grouped on equatorial plate.

278. (1.20) Chromosomes split longitudinally into daughter chromosomes.

279. (1.20) Daughter chromosomes become granular and begin to lose their compact structure.

280. (1.20) Daughter chromosomes begin to separate.

281. (1.20) Daughter chromosomes approach the poles.

282. (1.20) Nuclear membrane disappears.

283. (1.20) Nuclear membrane reappears.

284. (1.20) Spindle disappears.

285. (1.20) Spindle first appears.

Items 286 - 288. Certain traces of the visceral arches persist in man. Visceral arches:

A. First arch.
B. First and second arches.
C. Second arch.
D. Third arch.
E. Fourth and fifth arches.

From which have these structures originated?

286. (1.20) Bones of the middle ear.

287. (1.20) Cartilage of the larynx.

288. (1.20) Early framework of the lower jaw.

289. (1.20) The average number of nerve cells present in one gram of hydra endoderm

A. is greater than
B. is less than
C. is the same as

the average number of nerve cells present in one gram of hydra ectoderm.

290. Which of the following develop from the neural crest?
(1.20)

A. Central nervous system.
B. Dorsal root ganglion. **C.** Ventral root ganglion.
D. Both dorsal and ventral root ganglia.
E. None of the above.

291. The first cell of the sporophyte generation (in the alternation of generations in plants) is always
(1.20)

A. a spore. **B.** a gamete. **C.** a zygote.
D. an egg. **E.** a spore mother cell.

292. It is possible to exchange a bit of the presumptive epidermis and a piece of the presumptive neural plate in salamander embryos. Up to what stage does the transplanted part develop in accordance with its new surroundings?
(1.20)

A. Early blastula. **B.** Late blastula.
C. Early gastrula. **D.** Late gastrula.
E. Neural plate.

293 - 297. In the honeybee unfertilized eggs develop parthenogenetically to produce drones (males). The fertilized eggs produce females (queens and workers). In spermatogenesis in bees there is no segregation (reduction division). Oogenesis is the same as in other species. If all the mature eggs contain sixteen chromosomes, how many would you expect to find in each of the following?

KEY

A. Four. **B.** Eight. **C.** Sixteen.
D. Thirty-two. **E.** Twenty-four.

293. Sperm. **294.** Fertilized egg.
(1.20) (1.20)

295. Body cells of male. **296.** Body cells of female.
(1.20) (1.20)

297. First maturation division of male.
(1.20)

298. If developing eyes are exchanged between two species of salamanders which differ characteristically in eye size, each transplanted eye grows
(1.20)

A. to a size intermediate between the eyes of the two species.
B. to the size characteristic of its own species.
C. to the size characteristic of the species to which it was transplanted.

299. The outermost extra-embryonic membrane which, in chick embryos, envelops both the embryo and the yolk
(1.20)

A. forms the amniotic sac around the pig fetus.
B. forms the sac into which the pig fetus excretes its nitrogenous waste.
C. forms part of the placenta around the developing pig.
D. corresponds to the gut lining of the fetal pig.
E. has no corresponding part in the fetal pig.

300. The difference in frog and chick development noted in the preceding item may be explained as due to
(1.20)

A. the formation of the extra-embryonic membranes in the frog but not in the chick.
B. the formation of extra-embryonic membranes in the chick but not in the frog.
C. the greater size of the yolk in the chick than in the frog.
D. the presence of albumen in the chick egg but not in the frog egg.
E. the greater hardness of the external covering of the chick egg than of the frog egg.

301. A major distinction between the early developmental stages of the frog and of the chick lies in
(1.20)

A. the relative amount of the egg cell involved in cleavage.
B. the number of germ layers.
C. the method of formation of the neural tube.
D. the function served by the yolk.
E. the order in which gastrulation, cleavage, and neurulation occur.

302. The portion of the amphibian egg which first becomes self-differentiating and capable of determining the course of differentiation of adjacent areas is
(1.20)

A. the neural tube. **B.** the endoderm.
C. the vegetal hemisphere.
D. the dorsal lip of the blastopore.
E. the optic cup.

303. The tissue whose primordia are not derived from mesoderm in the following list is
(1.20)

A. skeletal muscle tissue. **B.** bone tissue.
C. tissues lining the coelomic cavity. **D.** blood.
E. nerve tissue.

304. During neurulation (the formation of the neural tube), the cell mass which is to give rise to the nervous system
(1.20)

A. changes its relative position from the inside of the embryo to the outside.
B. changes its relative position from the outside of the embryo to the inside.
C. divides more rapidly than before gastrulation.
D. spreads out to enclose the whole embryo.
E. is unaltered.

305 - 309. In certain grasshoppers sex is determined according to the XX-XO formula. There are 11 pairs of chromosomes exclusive of the X-chromosomes in both male and female. The following classes of cells are present in relation to chromosome numbers.

A. 24 chromosomes. **B.** 23 chromosomes.
C. 12 chromosomes. **D.** 11 chromosomes.
E. 11 or 12 chromosomes.

To which of the above groups would each of the following cells belong?

305. Fertilized egg which will develop into a female.
(1.20)

306. Fertilized egg which will develop into a male.
(1.20)

307. Mature ovum. **308.** Mature sperm.
(1.20) (1.20)

309. Second polar body.
(1.20)

310. The results of compressing amphibian eggs during early cleavage provides evidence
(1.20)

A. in favor of Darwin's theory of pangenesis (inheritance by gemmules).
B. against Darwin's theory of pangenesis (inheritance by gemmules).

C. in favor of Weismann's theory of development.
D. against Weismann's theory of development.
E. which has no bearing on either Darwin's or Weismann's theory of development.

The testis and the ovary are partly homologous organs in vertebrates, since their earliest development in the embryo is the same, differences appearing in the later stages of development. As a consequence, one might expect to find that there are similarities as well as differences in the adult male and female reproductive systems.

Directions: For each of the following statements about the typical adult human reproductive system, blacken answer space

A. if it applies only to the *male* reproductive system.
B. if it applies only to the *female* reproductive system.
C. if it applies to *both the male and the female* reproductive systems.
D. if it applies to *neither* the male nor the female reproductive systems.

311. (1.20) The gonad produces two distinct hormones with distinct functions.

312. (1.20) Certain cells in the reproductive system are capable of undergoing meiosis.

313. (1.20) The reproductive ducts begin inside the gonad and continue to an opening on the exterior of the organism.

314. (1.20) Production of gametes is stimulated by the pituitary's luteinizing hormone.

315. (1.20) Few mature gametes are produced at a time, and gamete production is intermittent.

316. (1.20) In the absence of the gonads, certain pituitary hormones aid in the maintenance of the other organs of the reproductive tract.

317. (1.20) In the typical mammal, the testes and the ovaries occupy

A. the same position in the body in both sexes of the species.
B. the same position in the body as in frogs of the appropriate sexes.
C. different positions in the body, the testes lying in a separate sac posterior to the body cavity in males.
D. different positions in the body, the ovaries being more posterior in females than the testes are in males.
E. different positions in the body, the ovaries being united to the kidneys in females, but the testes being unassociated with the excretory tract in males.

Items 318 - 321.

A. First cleavage. **B.** Second cleavage.
C. Third cleavage. **D.** Fourth cleavage.
E. Fifth cleavage.

318. (1.20) Which cell division separates the greatest part of the future ectoderm from the rest of the frog egg?

319. (1.20) Which cell division separates the future dorsal from the future ventral?

320. (1.20) Which cell division separates the future head end from the future tail end?

321. (1.20) Which cell division separates the future left from the future right in the frog egg?

322. (1.10) Which of the following men brought the binomial system of nomenclature into general use?

A. Aristotle. **B.** Linnaeus. **C.** Ray.
D. Wotton.

323. (1.20) In mitosis the most significant accomplishment is

A. the formation of the spindle.
B. the collection of chromatin into chromosomes.
C. the equal quantitative and qualitative division of the chromosomes.
D. the equal division of the cytoplasm.
E. the separation of the centrosomes.

324. (1.20) Chromosomes first appear in mitosis in the

A. prophase. **B.** metaphase. **C.** anaphase.
D. telophase.

325. (1.20) Mitosis differs from meiosis principally on the basis of

A. the number of cells produced.
B. the fact that mitosis occurs in animals and plants, meiosis only in animals.
C. reduction in the number of chromosomes.
D. production of motile gametes.
E. the fact that one produces only egg cells, the other only sperm cells.

Items 326 - 329. The following questions refer to the maturation of the germ cells. Refer to the key list in answering them.

A. N chromosomes. **B.** 2N chromosomes.
C. tetrad. **D.** diad. **E.** monad.

326. (1.20) At synapsis the condition of the chromosomes could be described by

A. A and B. **B.** B and C. **C.** C and D.
D. A and C. **E.** B and E.

327. (1.20) In the spermatid the condition of the chromosomes could be described by

A. A and C. **B.** B and C. **C.** B and D.
D. A and E. **E.** A and D.

328. (1.20) If reduction division precedes equation division at the production of the first polar body, the condition of the chromosomes could be described by

A. A and C. **B.** B and D. **C.** A and E.
D. A and D. **E.** B and C.

329. (1.20) When a zygote is formed, the condition of the chromosomes could be described by

A. A. **B.** B. **C.** C. **D.** D. **E.** E.

330. (1.20) The archenteron first appears in a starfish egg

A. when the raspberry stage is formed.
B. when gastrulation occurs.
C. immediately after fertilization occurs.
D. before the blastocoel is formed.
E. during the hollow-ball stage.

331. (1.20) Cellular differentiation is concerned with the fact that

A. cells remain the same shape during the subsequent development of the organism.
B. cells change from one basic type to a specialized type.

C. cells change from one type to another because they have different genetic characteristics.
D. cell cleavage alone accounts for changes occurring in cells.
E. all the possible cell changes which occur do so before the gastrulation stage.

Items 332 - 336 are based on the reproductive cycle in the average human female. Select from the key list the choice which matches each of these items. The days are counted from the time menstruation stops.

KEY

A. Ovum arrives in uterus.
B. If fertilization has not occurred, ovum can probably no longer be fertilized, and disintegrates.
C. Ovum gradually ripens, and quantity of follicular fluid increases.
D. New follicle begins to develop in ovary if fertilization has not occurred.
E. Ovulation occurs, and ovum passes into oviduct.

332. (1.20) 24th to 28th day.

333. (1.20) 9th to 14th day.

334. (1.20) 14th to 24th day.

335. (1.20) About the 8th day.

336. (1.20) 1st to 7th day.

337. (1.20) The formation of the neural tube marks the initial step in the formation of

A. the digestive system. **B.** the blastopore.
C. the nervous system. **D.** the hollow-ball stage.
E. the mesodermal germ layer.

338. (1.20) The germ layer, ectoderm, is responsible for the formation of

A. the epithelial layer in the digestive tract, digestive glands, and the respiratory system.
B. the outer layer of skin and the nervous system.
C. the connective tissue, muscle, blood vessels, and the heart.
D. the achenteron. **E.** all tissues in the body.

Note: For items 339 - 344, refer to the paper by Spemann and Mangold.

339. (1.20) A piece which would normally produce medullary plate can be interchanged in the early gastrula with a piece which would normally produce epidermis, and yet the resultant embryo is normal. This by itself implies that

A. these two pieces were already differentiated before their exchange.
B. these two pieces were already determined before their exchange.
C. the development of these two pieces was dependent on their position in the embryo.
D. only a small portion of the early gastrula is already determined.
E. the cells in the two pieces were identical at the time of transplantation.

340. (1.20) The finding that some parts of the late blastula or early gastrula are interchangeable is important to the development of the concept of "organizer" in embryology inasmuch as

A. the characteristic structure of the later embryo is not the result of self-differentiation of every part in the blastula, hence must be accomplished by factors acting during gastrulation.
B. the number of possible tissues which can be formed by a small portion of the blastula is increased as the development proceeds.
C. the nuclei of all the cells in the blastula are produced by mitotic divisions and hence all are alike, so that the cytoplasms of all the cells in the blastula are also identical.
D. the nuclei of all the cells in the blastula are produced by mitotic divisions, so all differentiation up to the end of cleavage is cytoplasmic.

341. (1.20) The cells derived from *T. cristatus,* can best be distinguished from those derived from *T. taeniatus* by

A. the organs in which they are found.
B. differences in the cytoplasmic pigmentation.
C. vital stains revealing differences in chemical properties of the cytoplasm.
D. the relative numbers of the kinds of cells in certain organs.
E. the germ layers in which they are found.

342. (1.10) As used by Spemann and Mangold, "determination" signifies

A. the capacity to produce a given type of tissue, such as brain, notochord, epidermis or somite.
B. the capacity to produce a tissue distinctive of the species to which it belongs.
C. visible differentiation between cell types or cell masses.
D. the ability to produce several different types of tissues, depending on immediate environment.
E. the ability to produce the type of tissue characteristic of the site of origin, regardless of environment.

343. (1.20) If the inducing action of the implant takes place after it has invaginated, then

A. one tissue or organ may conceivably be the cause of the determination of another tissue.
B. only physical factors—stretching, contiguity with fluid or with other cells—determine the course of development of individual cells.
C. only chemical factors which act at the cell surface determine the course of development of individual cells.
D. The most fruitful analysis of induction agents is apt to be in terms of specific stimulants to the carbohydrate metabolic enzymes.
E. the only problem left for embryologists is to discover how the organizing capacity comes to be localized in the region of the dorsal blastopore lip.

344. (1.20) The fact that in secondary embryos neural tissue is formed of presumptive epidermis is

A. predictable on the basis of Weismann's theory.
B. compatible with Weismann's theory, though not demanded by it.
C. contrary to expectation on the basis of Weismann's theory.

345. (2.20) The fact that neural tissue can be formed from presumptive epidermis is accounted for in the terms of Waddington's theory of differentiation as follows:

A. the genome of ectoderm can mutate in either of several directions, depending on external stimuli.
B. The raw materials necessary for the synthesis of the proteins characteristic of neural tissue can be sup-

plied by external agents when they are not already present in the cell.

C. Alternative chains of syntheses are open to early ectoderm, which pathway taken depending on the availability of raw materials.

D. Genes for all kinds of tissues are present in all cells. If presumptive epidermis is isolated from other influences, epidermal genes would be active, neural genes latent; however, under the influence of organizer-like chemicals, the neural genes may be activated.

E. Cytoplasmic protein characteristic of neural tissue is close enough to epidermal proteins so that the enzymes required for the synthesis of one kind can synthesize the other, given a proper environment.

346. The fact that it is difficult or impossible for presumptive
(2.20) epidermis to develop into cells which are intermediate to skin and nervous system is accounted for in the terms of Waddington's theory as follows: (Select the two correct alternatives).

A. Certain sets of syntheses can go on simultaneously, while other sets are incompatible with each other.
B. Genes for both skin and brain are present in early ectoderm, but there are no genes for intermediate tissue.
C. Intermediate enzymes produced by intermediate genes would lose out in competition with extremes.
D. The production of one enzyme encourages the production of more of itself so that when one metabolic alternative is initially favored other alternatives are progressively more difficult to initiate.
E. The raw materials available for the synthesis of protein are limited as to quality, i.e., there are no materials available for the formation of "half-brain—half-skin."

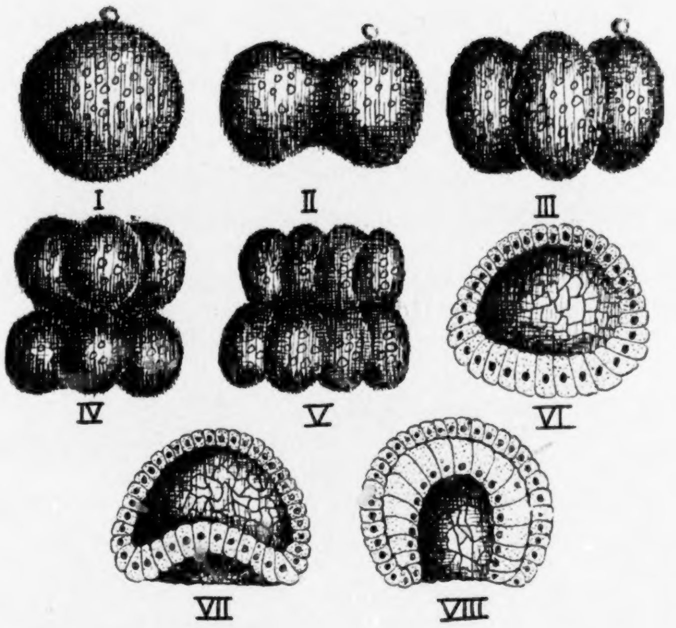
347. **Biological evidence tending to overrule Justice Oliver**
(2.20) **Wendell Holmes' 1884 decision that an unborn child is** not an individual but "part of its mother's bowels" can well be based on all of these observations *except*

A. the manner in which the placenta draws food from the mother.
B. the manner in which the embryo imbeds itself in the wall of the uterus.
C. the nature of the intermingling of the mother's and embryo's blood.
D. the existence of the umbilical cord.
E. the manner in which diseases are transmitted from mother to embryo.

Items 348 - 354. After the exercise number on the answer sheet, blacken the *one* lettered space which designates the correct completion of the statement. Refer to diagram in next column.

348. Between the stages labelled I and II
(2.20)

A. the egg and the sperm fuse together, reducing the chromosomes number by half.
B. the chromosomes form on a mitotic spindle and migrate to the poles.
C. the substances in the cytoplasm are always divided equally so that the two cells are similar.
D. the egg is divided in half midway between the animal and vegetal poles.
E. the yolk begins to diffuse through the cytoplasm of the egg until it is equally distributed.



349. Stage V is called a
(2.20)

A. blastula. **B.** gastrula. **C.** morula.
D. zygote. **E.** blastomere.

350. Stage VI is called a
(2.20)

A. gastrula. **B.** morula. **C.** zygote.
D. micromere. **E.** blastula.

351. The cavity present in stage VI is to
(2.20)

A. become the digestive cavity.
B. be invaded, reduced in size, and finally disappear.
C. become the yolk sac.
D. become the allantoic cavity.
E. become the amniotic cavity.

352. Between stages VI and VIII
(2.20)

A. the entoderm cells for the first time obtain the cytoplasmic substances which cause them to become entoderm.
B. the nervous system first begins to form.
C. the mesoderm cells first distinguish themselves from entoderm cells.
D. the process of mitosis occurs for the first time.
E. two germ layers become segregated.

353. Stage VIII is called a
(2.20)

A. blastula. **B.** blastopore. **C.** morula.
D. gastrula. **E.** larva.

354. The cavity in stage VIII
(2.20)

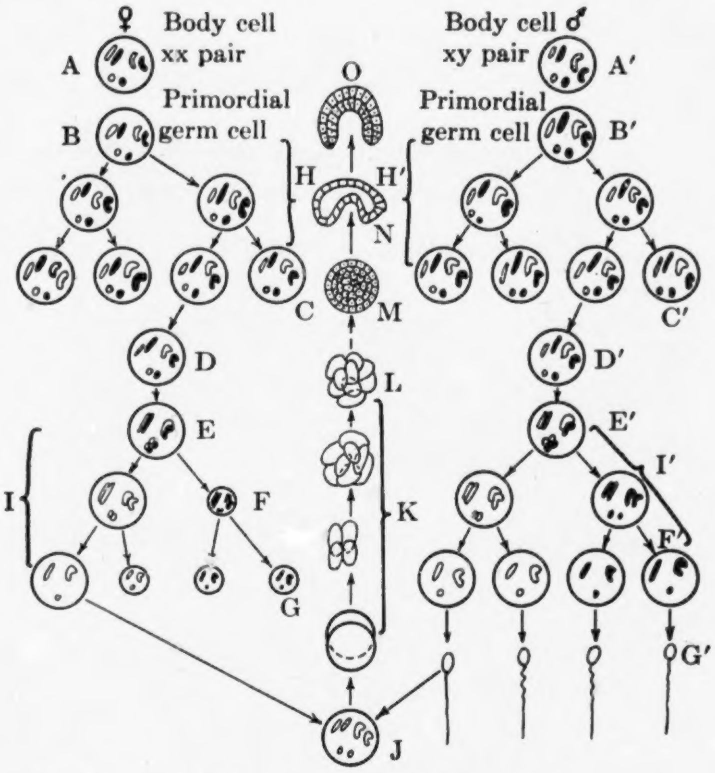
A. ultimately becomes the body cavity.
B. becomes the digestive cavity.
C. is the beginning of the yolk sac.
D. will later be partially filled by mesoderm.
E. opens to the outside through the blastocoel.

Items 355 - 381.

The following exercises refer to the diagrams on p. 193. After each exercise number on the answer sheet, blacken the *one* lettered space which designates the correct answer.

355. The processes illustrated relate to the physiology of
(2.20)

A. respiration. **B.** metabolism. **C.** reproduction.
D. digestion. **E.** circulation.



356. More specifically, H and H′ and I and I′ illustrate
(2.20)

A. the building up of worn-out body cells.
B. the production of red and white blood cells.
C. mitosis and meiosis.
D. the activity of gland cells.
E. none of the preceding.

357. H and H′ show the production of
(2.20)

A. mature eggs and sperms.
B. egg and sperm mother cells.
C. more primordial germ cells.
D. red blood cells. **E.** any body cell.

358. Therefore, H and H′ illustrate the process of
(2.20)

A. mitosis. **B.** meiosis. **C.** spermatogenesis.
D. oogenesis. **E.** parthenogenesis.

359. E and E′ are
(2.20)

A. mature eggs and sperms.
B. eggs and sperm mother cells.
C. red blood cells. **D.** any body cell.
E. spores.

360. When E and E′ divide, they undergo the process of
(2.20)

A. mitosis. **B.** meiosis. **C.** spermatogenesis.
D. oogenesis. **E.** parthenogenesis.

361. The result of I is
(2.20)

A. sperms. **B.** eggs. **C.** spores.
D. body cells. **E.** zygotes.

362. The result of I′ is
(2.20)

A. sperms. **B.** eggs. **C.** spores.
D. body cells. **E.** zygotes.

363. The process illustrated by H occurs in
(2.20)

A. the ovary.
B. the seminiferous tubules of testes.
C. the oviduct. **D.** the sperm ducts.
E. any other part of the body.

364. The process illustrated by H′ occurs in
(2.20)

A. the follicle of ovary.
B. the seminiferous tubules of the testes.
C. the oviduct. **D.** the sperm ducts.
E. any other part of the body.

365. The cells from G and G′ fuse during the process of
(2.20)

A. mitosis. **B.** meiosis. **C.** cleavage.
D. fertilization. **E.** parthenogenesis.

366. The fusion of cells G and G′ results in the formation of
(2.20)

A. sperm and egg mother cells.
B. sperm and eggs. **C.** a zygote. **D.** morula.
E. blastula.

367. Cells G and G′ fuse in
(2.20)

A. the egg follicles. **B.** the oviduct.
C. the uterus. **D.** the vagina.
E. any other part of the body.

368. Structure J undergoes
(2.20)

A. meiosis. **B.** cleavage. **C.** fertilization.
D. parthenogenesis. **E.** reduction division.

369. The process illustrated by K is essentially a series of
(2.20)

A. parthenogenetic divisions. **B.** meiotic divisions.
C. mitotic divisions. **D.** reduction divisions.
E. none of the preceding.

370. The process illustrated by K results in the formation
(2.20) of a

A. gastrocoel. **B.** blastocoel. **C.** gastrula.
D. blastula. **E.** morula.

371. In lower animals the stage represented by L develops
(2.20) by various processes into a sphere comprised of a single layer of cells called a

A. gastrocoel. **B.** blastocoel. **C.** gastrula.
D. blastula. **E.** morula.

372. Structure M is then followed by a
(2.20)

A. gastrocoel. **B.** blastocoel. **C.** gastrula.
D. blastula. **E.** morula.

373. Structure O is characterized by
(2.20)

A. ectoderm and endoderm.
B. etoderm and mesoderm.
C. endoderm and mesoderm.
D. all three germ layers.
E. none of the preceding germ layers.

374. The cavity in structure O is the
(2.20)

A. blastocoel. **B.** primitive gut or archenteron.
C. coelom. **D.** body cavity. **E.** intestinal cavity.

375. The cell layer essential to completion of development
(2.20) but not shown in any of the diagrams is

A. ectoderm. **B.** endoderm. **C.** mesoderm.
D. epithelium. **E.** endothelium.

376. As development of structure O continues, various organs
(2.20) arise; for example, the nervous system arises by in-pocketing (invagination) of

A. ectoderm. B. endoderm. C. mesoderm.
D. ectoderm and endoderm.
E. ectoderm and mesoderm.

377. The lining of the digestive tract arises from
(2.20)

A. ectoderm. B. endoderm. C. mesoderm.
D. ectoderm and endoderm.
E. ectoderm and mesoderm.

378. As the nervous system and the digestive tract are
(2.20) appearing, the heart is developing simultaneously from

A. ectoderm. B. endoderm. C. mesoderm.
D. ectoderm and endoderm.
E. ectoderm and mesoderm.

379. Excretory and reproductive organs arise from
(2.20)

A. ectoderm. B. endoderm. C. mesoderm.
D. ectoderm and endoderm.
E. ectoderm and mesoderm.

380. Muscle layers are derivatives of
(2.20)

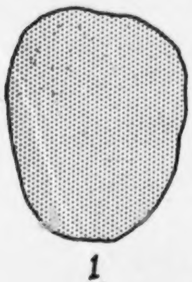
A. ectoderm. B. endoderm. C. mesoderm.
D. ectoderm and endoderm.
E. ectoderm and mesoderm.

381. Skin, tooth enamel, and nails are derivatives of
(2.20)

A. ectoderm. B. endoderm. C. mesoderm.
D. ectoderm and endoderm.
E. ectoderm and mesoderm.

Items 382 - 406.

The following diagrams are illustrations of the embryonic development of Amphioxus, one of the primitive chordates. After the number on the answer sheet which corresponds to that of each of the following exercises, blacken the *one* lettered space which designates the correct answer.



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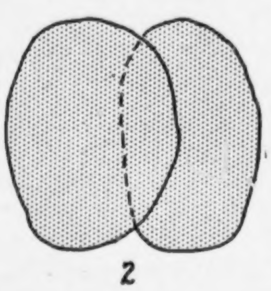

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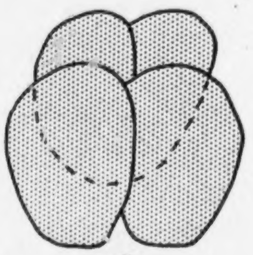

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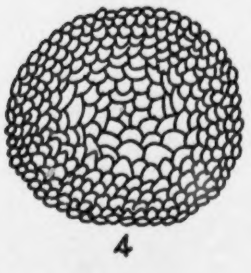

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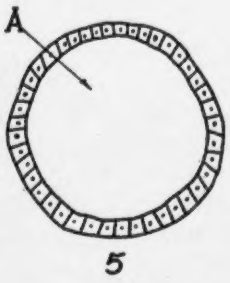

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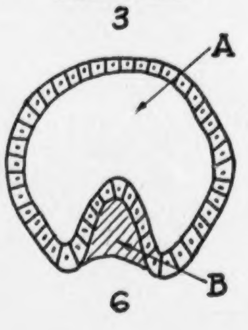

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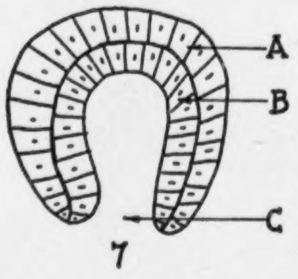

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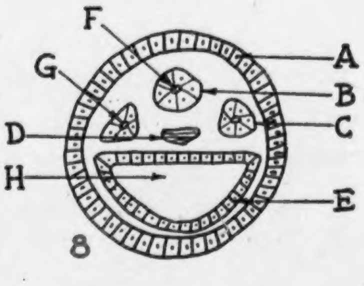


8

382. The yolk in the type of egg shown in figure 1 is
(2.20)

A. evenly distributed throughout the cytoplasm of the egg.
B. unevenly distributed in the cytoplasm of the egg.

383. Cleavage is illustrated in figures
(2.20)

A. 1 through 4. B. 5 through 6.
C. 6 through 7. D. 7 through 8.

384. Figure 4 is an illustration of the
(2.20)

A. blastula stage. B. gastrula stage.
C. morula stage.

385. Figure 5 is an illustration of the
(2.20)

A. blastula stage. B. gastrula stage.
C. morula stage.

386. The item "A" in figure 5 is the
(2.20)

A. gastrocoel. B. blastocoel. C. blastoderm.
D. blastopore.

387. Figure 6 is an illustration of the
(2.20)

A. blastula stage. B. early gastrula stage.
C. late gastrula stage.

388. The item "A" in figure 6 is the
(2.20)

A. gastrocoel. B. blastoderm. C. blastopore.
D. blastocoel.

389. The item "B" in figure 6 is the
(2.20)

A. gastrocoel. B. blastocoel. C. blastoderm.

390. Figure 7 is an illustration of the
(2.20)

A. blastula stage. B. early gastrula stage.
C. late gastrula stage.

391. The item "A" in figure 7 is the
(2.20)

A. ectoderm. B. endoderm. C. mesoderm.
D. blastocoel. E. blastopore.

392. The item "B" in figure 7 is the
(2.20)

A. entoderm. B. endoderm. C. mesoderm.
D. blastocoel. E. blastopore.

393. The item "C" in figure 7 is the
(2.20)

A. ectoderm. B. endoderm. C. mesoderm.
D. blastocoel. E. blastopore.

394. The item "A" in figure 8 is the
(2.20)

A. ectoderm. B. endoderm. C. mesoderm.

395. The item "B" in figure 8 is the
(2.20)

A. notochord. B. nerve cord. C. myotome.
D. primitive gut.

396. The item "C" in figure 8 is the
(2.20)

A. ectoderm. B. endoderm. C. mesoderm.

397. The item "D" in figure 8 is the
(2.20)

A. notochord. B. nerve cord. C. myotome.
D. primitive gut.

398. The item “E” in figure 8 is the
(2.20)

A. ectoderm. **B.** endoderm. **C.** mesoderm.

399. The item “F” in figure 8 is the
(2.20)

A. gastrocoel. **B.** blastocoel. **C.** coelom.
D. neural canal.

400. The item “G” in figure 8 is the
(2.20)

A. gastrocoel. **B.** blastocoel. **C.** coelom.
D. neural canal.

401. The item “H” in figure 8 is the
(2.20)

A. gastrocoel. **B.** blastocoel. **C.** neural canal.
D. coelom.

402. The epidermis of the skin is formed from the
(2.20)

A. ectoderm. **B.** endoderm. **C.** mesoderm.

403. The epithelial portion of the adult stomach is formed
(2.20) from the

A. ectoderm. **B.** endoderm. **C.** mesoderm.

404. In mammalian development the embryonic notochord
(2.20) is replaced with the

A. nerve cord. **B.** primitive gut. **C.** myotomes.
D. vertebral column. **E.** neural tube.

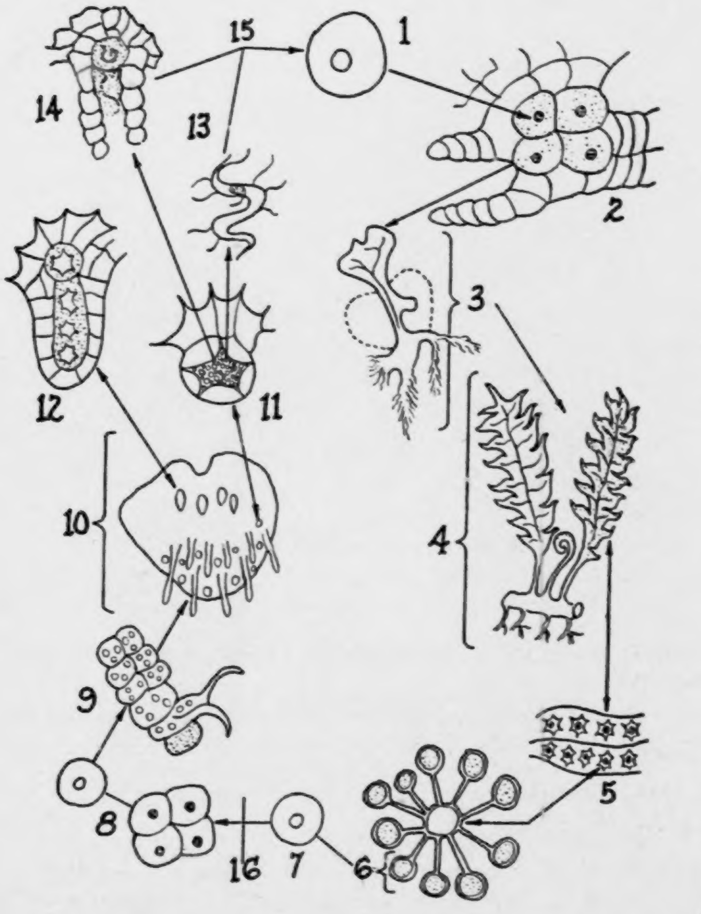
405. The brain in all chordates is formed from the
(2.20)

A. ectoderm. **B.** endoderm. **C.** mesoderm.

406. The blood vessels in all chordates are formed from the
(2.20)

A. ectoderm. **B.** endoderm. **C.** mesoderm.

Items 407 - 422.



The following exercises refer to the preceding diagrams. After each item number on the answer sheet blacken the *one* lettered space which designates the correct completion.

407. The symbol “1” in the diagram represents.
(2.20)

A. a germinating spore. **B.** fertilization.
C. the zygote. **D.** an embryo.
E. a spore mother cell.

408. The symbol “2” represents
(2.20)

A. a spore. **B.** a zygote. **C.** a fruiting body.
D. a germinating spore. **E.** an embryo.

409. The symbol “3” represents
(2.20)

A. a fruiting body. **B.** a zygote.
C. a male sex organ. **D.** a gametophyte.
E. a young sporophyte.

410. The symbol “4” stands for
(2.20)

A. the mature gametophyte.
B. the male sex organ. **C.** the female sex organ.
D. the mature sporophyte. **E.** a saprophyte.

411. The symbol “5” represents a
(2.20)

A. sorus. **B.** single spore case.
C. female sex organ. **D.** male sex organ.
E. gametophyte “leaf.”

412. The symbol “6” refers to
(2.20)

A. germinating spores. **B.** sperms. **C.** zygotes.
D. eggs. **E.** a spore case.

413. The symbol “7” represents
(2.20)

A. an embryo. **B.** a spore. **C.** a zygote.
D. a spore mother cell. **E.** an egg.

414. The symbol “8” stands for
(2.20)

A. an egg. **B.** a sperm. **C.** a spore.
D. a sporophyte. **E.** a gametophyte.

415. The symbol “9” represents
(2.20)

A. a sperm. **B.** an embryo.
C. a female sex organ. **D.** a germinating spore.
E. a young sporophyte.

416. The symbol “10” stands for
(2.20)

A. an embryo. **B.** a gametophyte plant.
C. a spore case. **D.** a sporophyte plant.
E. a fruiting body.

417. The symbol “11” refers to a
(2.20)

A. female sex organ. **B.** fruiting body.
C. spore mother cell. **D.** spore case.
E. male sex organ.

418. The symbol “12” refers to a
(2.20)

A. female sex organ. **B.** fruiting body.
C. spore mother cell. **D.** spore case.
E. male sex organ.

419. The symbol "13" refers to
(2.20)

A. an egg. **B.** a sperm. **C.** a spore.
D. a zygote. **E.** a pollen grain.

420. The symbol "14" refers to
(2.20)

A. an egg. **B.** a sperm. **C.** a spore.
D. a zygote. **E.** a spore mother cell.

421. At the point in the cycle represented by "15" the following process occurs:
(2.20)

A. meiosis. **B.** fertilization. **C.** sporogenesis.
D. mitosis. **E.** germination.

422. At the point in the cycle represented by "16" the following process occurs:
(2.20)

A. meiosis. **B.** fertilization. **C.** spermatogenesis.
D. pollination. **E.** germination.

Items 423 - 435.

After the number on the answer sheet corresponding to each blank in the following paragraphs, blacken the *one* lettered space which designates the word or phrase which should fill the blank. Choose the word or phrase from the key list given below the paragraph. (All are 2.20)

In mammals, including man, female gametes are produced in a special organ called **423**. At regular intervals, a group of **424** develop, but normally only one matures to form **425** which enters **426** after ovulation has occurred. If fertilization then take place, the zygote passes into **427** whose lining is especially prepared to nourish and protect the developing embryo.

KEY

A. An egg mother cell or egg mother cells.
B. An ovary or ovaries. **C.** The uterus.
D. An oviduct. **E.** A follicle or follicles.

At the beginning of the estrus cycle, the pituitary secretes **428** which stimulates active cell division in the germinal epithelium of the ovary. The resulting cells secrete a hormone, **429**, which stimulates changes in the lining of the uterus. After ovulation, a second hormone from the pituitary, **430**, stimulates the production of the yellow body. This body secretes **431**, a hormone which maintains the lining referred to above and stimulates the glands to begin functioning. Immediately following ovulation, the hormone **432** also inhibits the pituitary from further production of **433**, while the hormone **434** also inhibits the further production of **435**, but if fertilization does not occur secretion of the *latter* starts a new cycle.

KEY

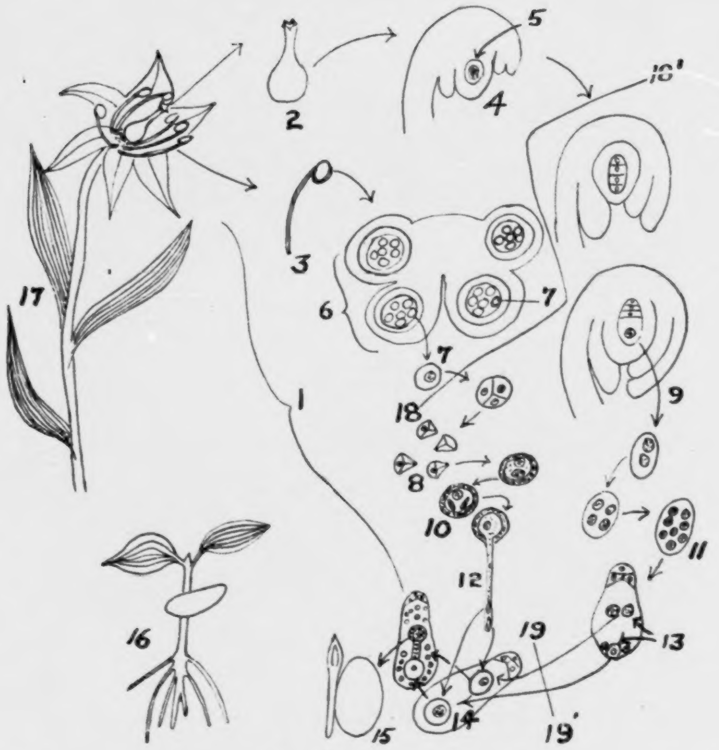
A. Estrogen. **B.** Progestin.
C. Luteinizing hormone.
D. Follicle-stimulating hormones.

Items 436 - 450.

The diagrams given to the right, above, represent a generalized life cycle of a plant. Portions of the cycle and structures are labeled with numbers. After each exercise number on the answer sheet, blacken the *one* lettered space which designates the correct answer.

436. The life cycle shown represents that of
(2.20)

A. a seed plant. **B.** a fern. **C.** an alga.
D. a flowering plant. **E.** any one of the preceding.



437. Structures included within bracket #1 are a part of
(2.20)

A. the sporophyte generation.
B. the gametophyte generation.
C. either the sporophyte or gametophyte generation.
D. neither the sporophyte nor the gametophyte generation.

438. Structures #2 and #3 represent
(2.20)

A. the sex organs. **B.** petals and sepals.
C. stamen and pistil.
D. large and small spore cases. **E.** gametophytes.

439. Structure #4 is
(2.20)

A. a spore case. **B.** a large spore case.
C. a small spore case. **D.** the ovary. **E.** an egg.

440. Structure #5 is the
(2.20)

A. large spore case. **B.** small spore case.
C. large spore mother cell.
D. small spore mother cell. **E.** egg.

441. Structure #6 is a cross-section through the
(2.20)

A. spore case. **B.** large spore case.
C. small spore case. **D.** ovary.
E. male sex organ.

442. Structure #7 is the
(2.20)

A. large spore case. **B.** small spore case.
C. large spore mother cell.
D. small spore mother cell. **E.** sperm.

443. Line 18-18' represents an important process called
(2.20)

A. cleavage. **B.** fertilization. **C.** germination.
D. meiosis. **E.** mitosis.

444. The chief result of the process presented by line 18-18' is
(2 20)

A. an extensive duplication of individual cells.
B. a doubling of chromosomes. **C.** growth.

D. a reduction in chromosome numbers.
E. no change in chromosome content.

445. (2.20) Structures #8 and #9 are

A. pollen grains. **B.** spores. **C.** gametes.
D. eggs and sperms. **E.** zygotes.

446. (2.20) Structures #10 and #12 represent

A. stamens. **B.** male gametophytes.
C. female gametophytes. **D.** male sex organs.
E. sex cells.

447. (2.20) Structures #11 and #13 represent

A. pollen grains. **B.** male gametophytes.
C. female gametophytes. **D.** female sex organs.
E. male sex organs.

448. (2.20) Some of the nuclei shown in Structure #13 will be involved in

A. mitosis. **B.** fertilization. **C.** meiosis.
D. cleavage. **E.** binary fission.

449. (2.20) The process represented by line 19-19′ results in the formation of

A. endosperm. **B.** gametes. **C.** spores.
D. a zygote. **E.** a zygote and endosperm.

450. (2.20) Structure #15 progressively develops into #16 by

A. germination. **B.** cleavage. **C.** meiosis.
D. fertilization.

451. (2.20) At some point in the life cycle of organisms which reproduce sexually the diploid number of chromosomes must be reduced to the haploid number.

A. Otherwise, each generation, the number of chromosomes would double.
B. Mitosis cannot take place without such a reduction occurring.
C. The sperm cell must have the same number of chromosomes as the egg cell.
D. All body cells have the same number of chromosomes.
E. A change in the number of chromosomes in the body cells of an organism can only occur as the result of mutation.

452. (2.20) The spores of ferns function in the distribution of the plant while the spores of flowering plants do not.

A. The spores of ferns are produced within spore cases.
B. In flowering plants sperm and egg unite to form a zygote.
C. The sporophyte is the conspicuous generation in ferns.
D. Spores are more readily distributed by the wind than is pollen.
E. The gametophytes of ferns can develop independently while those of flowering plants cannot.

453. (2.20) Why does each egg mother cell give rise to only one egg?

A. Meiosis occurs in spermatogenesis.
B. Many more sperms are produced in the male than eggs in the female.
C. The sperms are very much smaller than the egg cells.
D. The egg mother cell (primary oocyte) divides unequally forming some nonfunctional cells.
E. Sperms are motile while eggs are not.

454. (2.20) Although two cells unite in the process of fertilization, why has the zygote generally no more chromosomes than the number typical of the body cells of the parents or of their offspring?

A. Meiosis occurs during the process of gametogenesis.
B. In parthenogenesis, eggs develop which have not united with a sperm.
C. Cleavage occurs following the fertilization of an egg by a sperm.
D. Sperms contain fewer chromosomes than eggs.
E. Mitosis occurs during the process of gametogenesis.

455. (2.20) Why do the cells of a fern gametophyte possess half as many chromosomes as the cells of the sporophyte?

A. The sporophyte is the conspicuous generation in ferns and flowering plants.
B. Meiosis occurs during the production of spores from which the gametophyte develops.
C. The fern gametophyte possesses both male and female sex organs.
D. Mitosis occurs during the gametophyte generation, but not during the sporophyte generation.
E. The male and female gametophytes of flowering plants are much less complex than the gametophytes of ferns.

456. (2.20) Although some fern gametophytes possess both male and female sex organs self-fertilization does not occur.

A. The outer egg membrane prevents penetration of sperms from the same gametophyte.
B. The sperms are ciliated and swim away from the gametophyte producing them.
C. The male sex organs are on the anterior portion and the female sex organs on the posterior portion of the gametophyte.
D. The eggs and sperm mature at different times.
E. Any sperm is incapable of fertilizing an egg produced on the same gametophyte.

457. (2.20) Although the nervous system is within the body, it developed from the ectoderm of the embyro.

A. The ectoderm is the innermost germ layer.
B. The ectoderm also gives rise to the lining of the mouth.
C. One part of the ectoderm changes successively to form a plate, then a groove, and finally a tube no longer external.
D. Structures normally formed from one germ layer may arise from another.
E. The notochord develops just below the neural tube.

Items 458 - 468 are concerned with treatment of rheumatoid arthritis described in the following news items. The numbered, underlined sentences constitute items 458 - 466. Classify each of these sentences according to the following key. (All are 2.20)

KEY

A. Problem. **B.** Hypothesis.
C. Experimental observation.
D. Experimental procedure. **E.** None of the above.

458. *"Doctors noted long ago that women get relief from rheumatoid arthritis during pregnancy, then relapse within a couple of months.* **459.** *Why does pregnancy have this effect?* Some arthritis researchers have tried to find a drug or chemical which would get the same results (hence, ACTH and cortisone treatments). Dr. Louis W. Granirer of Queens General Hospital in New York City reasoned that **460.** *the healing substance was probably in the blood of pregnant women, and probably stayed there for a while after childbirth.* Last week Dr. Granirer gave striking evidence to the Society of Medical Jurisprudence that his hunch had paid off. A healthy woman after a normal delivery can readily spare some blood; **461.** *from each volunteer, Dr. Granirer took about seven ounces. The plasma was pooled and about half a pint given to bedridden arthritis victims.* After a few weekly transfusions, **462.** *each recipient gained weight, lost pain and swelling,* felt better in every way. By way of proof, Dr. Granirer showed movies of former cripples jumping rope."

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"If Chicago's hormone conference offered little new hope for arthritis sufferers, there was brighter news last week in Milwaukee, 80 miles farther north. **463.** *There at a staff meeting at St. Mary's Hospital, Drs. Millard Tufts, S. B. Pessin and Tiber Greenwalt announced a new anti-arthritic serum that can be extracted at any hospital from discarded after births, i.e., placentas and umbilical cords.* Doctors have long noted that pregnancy relieves women suffering from rheumatoid arthritis. Blood serum taken from new mothers soon after delivery has even proved effective in treating the disease. Rather than take blood from new mothers, Dr. Tufts decided to try something else. **464.** ***The same factor that prevents arthritis in pregnant women and infants (who never have arthritis), he reasoned, must lie in the blood of the placenta, gallons of which are thrown away every day in any obstetrical center.*** **465.** ***In company with his colleagues, Dr. Tufts refined from placenta blood some serum which he called PBS, and injected 20 cc. into the arm of a patient who had suffered from severe rheumatoid arthritis for more than ten years.*** After three injections she reported, 'My pain and swelling began to disappear AND I could notice the lump on my wrist start to go down. . . .' **466.** ***Dr. Tufts's patients (nine so far) suffered no setbacks when treatment was stopped, and none of the side effects*** (diabetes and hardening of the arteries) generally resulting from hormone treatment."

By permission; TIME Magazine, Dec. 18, 1950.
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467. Cortisone and ACTH, referred to in the first paragraph
(2.20) of the preceding item, are

A. vaccines. **B.** hormones. **C.** vitamins.
D. inorganic substances. **E.** none of the above.

468. The "healing substance" may be present in the blood
(2.20) in larger proportion during pregnancy because

A. the fetus and its mother need added protection during the period of pre-natal development.
B. medical treatment is usually administered during that period.
C. the developing fetus is metabolically very active during pre-natal development.
D. certain hormones are secreted more profusely at that time.
E. the mother is usually more cognizant of the necessity for maintaining the best possible health during that period.

469. A kernel of corn dropped in the barnyard grew into a
(2.20) large corn plant which when mature had very few kernels on the ear. The *best* explanation for this failure of the ear to fill out with kernels is:

A. The over-abundance of available fertilizer in the barnyard "burned out" the plant.
B. The plant did not receive the same attention and care as field plants do.
C. The kernel dropped was probably not of a highly select seed corn variety.
D. Fungus diseases are more prevalent in the barnyard than in an open field.
E. Cross-fertilization did not occur.

Items 470 - 473 are designed to measure your ability to read popular literature dealing with biological science. The passage is adapted from: *The Next Hundred Years,* J. C. Furnas. Reynal and Hitchcock. (By permission from Williams and Wilkins.)

A) One of the standing mysteries of the animal world is sex, biologically as well as romantically. B) With the mammals the sex of the offspring is normally determined at conception, for there are male and female producing sperms and yet there are feminine men and masculine women, bearded ladies who are not faked and men who knit. C) There are not infrequent cases of homosexuality where the equipment is of one sex but the hormone secretions are apparently preponderantly of the other, for these sex characteristics are largely determined by the internal secretions of the gonads containing traces of juices that call the breeding season of the moose and the social season of the human. D) They have a decided effect on the mind, normal and abnormal, as well as on the voice-box calling the turns in the cycle of fetal nutrition, delivery and lactation and even affecting mental attitudes as well as physical vigor. E) The old cow who hardly moves in her tracks in normal times will crash through a barbed wire fence when the hormones flow and she is in heat.

470. The best statement of the hypothesis upon which Furnas
(2.20) is operating is

A. sex is the predominating influence in human living.
B. human behavior stimulated by sex hormones tends toward the spectacular.
C. the sexual behavior of an individual is dictated entirely by the action of hormones.
D. many factors of mammalian behavior are controlled by hormones, the secretions of the endocrine glands.
E. the mentality, personality, and physical vigor of an individual is spectacularly totally dependent upon the action of hormones.

471. Which of the lettered sentences in the above passage
(2.20) most profoundly illustrates the tendency of popular writers to overgeneralize?

472. Furnas attempts to explain all of the following factors
(2.20) of human behavior except

A. the behavior whereby a newborn infant acquires nourishment.
B. the change in pitch of an adolescent boy's talk.
C. a person's abnormal interest in another person of the same sex.
D. the development of mammary glands concurrently with pregnancy.
E. differentiation between masculine and feminine recreational interests.

473. An inaccurate assumption showing through the passage
(2.20) is that

A. the sperm plays the major part in determining the sex of the offspring.
B. hormone action is limited to specific and readily identifiable changes in human behavior.
C. modern medical science does not understand hormone behavior in humans.

D. sideshow freaks are often cases of abnormal functioning of the endocrine glands.
E. humans are subject to periodic sexual behavior comparable to that of other mammals.

For items 474 - 484 read the following selection carefully. It was written in 1688 by Redi, an Italian physician who was known for his attainments in literature and natural science.

"Having considered some observations of flies on meat, I began to believe that all worms found in meat were derived directly from the droppings of flies, and not from the putrefaction of the meat, and I was still more confirmed in this belief by having observed that, before the meat grew wormy, flies had hovered over it, of the same kind as those that later lived in it. Belief would be vain without the confirmation of experiment; hence in the middle of July, I put a snake, some fish, some eels of the Arno, and a slice of milk fed veal in four large, wide-mouthed flasks, having well-closed and sealed them, I filled the same number of flasks in the same way, only leaving these open. It was not long before the meat and the fish, in these second vessels, became wormy and flies were seen entering and leaving at will; but in the closed flasks I did not see a worm, though many days had passed since the dead flesh had been put in them. Outside on the paper cover there was now and then a deposit, or a maggot that eagerly sought some crevice by which to enter and obtain nourishment. Meanwhile the different things placed in all flasks became putrid and stinking; the fish, their bones excepted, had all been dissolved into a thick, turbid fluid, which on settling became clear, with a drop or so of liquid grease floating on the surface, but the snake kept its form intact, with the same color, as if it had been put in but yesterday; the eels, on the contrary, produced little liquid, though they had become very much swollen, and losing all shape, looked like a viscous mass of glue, the veal, after many weeks, became hard and dry."

Directions: Items 474 - 479 are taken from or based on the above selection. For each item mark space.

KEY

A. if the statement is an observation.
B. if the statement is a basic assumption of a scientist.
C. if the statement is an hypothesis.
D. if the statement is a conclusion based on evidence.
E. if the statement does not belong in any of the above categories.

474. (2.20) "I began to believe that all worms found in meat were derived directly from the dropping of flies."

475. (2.20) "Belief would be vain without the confirmation of experiment."

476. (2.20) "It was not long before the meat and the fish, in these second vessels, became wormy, and flies were seen entering and leaving."

477. (2.20) "The snake kept its form intact."

478. (2.20) Maggots do not develop in meat which is protected from flies.

479. (2.20) The nature of the fluid resulting from the putrefaction of the fish was not investigated.

Directions for items 480 - 484. These items are also based upon the Redi quotation. For each item select the best answer, then mark the corresponding space on the answer sheet.

480. (2.20) In setting up such an experiment and drawing conclusions from it, a scientist would most likely assume that the results

A. would probably be the same if the same experiment were attempted by someone else under the same conditions.
B. might not be the same if the same experiment were attempted by someone else under the same conditions.
C. would probably not be the same if the same experiment were attempted by someone else under the same conditions.
D. would probably bear no predictable relationship to what would happen again if the same experiment were attempted by someone else under the same conditions.
E. constitute a unique event which had occurred once in his own experience, but should have no generalization or future action based upon it.

481. (2.20) If Redi had discovered maggots developing in one or more of his closed flasks but not in others, and had followed accepted techniques of modern scientific research, he should have

A. discarded those flasks as being faulty, and used only the remaining ones in drawing his conclusions.
B. discarded all of the flasks, and decided that his original explanation was wrong.
C. kept all of the flasks but should have drawn a different kind of conclusion.
D. repeated the experiment several times before attempting to draw a conclusion.
E. decided that because of inadequate equipment no conclusion was possible.

482. (2.20) Redi probably would have concluded at the end of his experiment that

A. life can arise from non-living matter.
B. human life originates differently than animal life.
C. life originates spontaneously under certain circumstances.
D. life can arise from pre-existing life.
E. life is unpredictable.

483. (2.20) If Redi had chosen to investigate whether or not odor attracts flies to meat, a simple and effective procedure would have been for him to

A. cook some meat and seal it in air-tight opaque flasks.
B. place raw meat in air-tight opaque flasks.
C. place raw meat in open opaque flasks.
D. place raw meat in sealed opaque flasks and in open opaque flasks.
E. perform all of the above procedures combined.

484. (2.20) If Redi had chosen to investigate whether or not color attracts flies to meat, a simple and effective procedure would have been for him to

A. place some raw meat in opaque flasks and seal them.
B. place a differently colored piece of meat in each of several transparent colorless flasks and seal them.
C. place a differently colored piece of meat in each of several transparent colorless, open flasks.
D. perform each of the above procedures.
E. decide that an adequate test was impossible.

485. (2.20) Spiegelman states that the problem of differentiation, when attacked on a cellular level, leads to the basic question of the relation between genes in the nucleus and properties of the cytoplasm. In connection with this basic question, Spiegelman does not hold that

A. cells of the various tissues differ in their metabolism.
B. metabolism is mediated by enzymes.
C. enzyme formation depends on genes in the nucleus.
D. differentiation is a progressive change in the distribution of enzymes.
E. the cytoplasm is the sole determiner of the specific nature of the nucleus.

486. (2.30) Spiegelman would be forced to accept Weismann's view of differentiation if it were shown that

A. all differences between the various tissues can be attributed to metabolic differences.
B. some chemical reactions in the body take place without the catalytic action of enzymes.
C. enzyme formation is independent of the nucleus.
D. no change in enzyme constitution can occur without a previous change in genome.
E. the character of the cell depends on an interaction between genes in the nucleus and enzymes in the cytoplasm.

487. (2.30) In order to solve the general problem of the relation between genes and cytoplasm and, in particular, to put Weismann's view to a test, Spiegelman selects yeast as the material to be studied. Yeast is suitable material because it is known that (select *all* correct alternatives: the score on this item will therefore be number right minus number wrong)

A. the enzyme content of yeast remains the same under different environmental conditions.
B. the enzyme content of yeast varies under different environmental conditions.
C. all yeast cells of one particular clone (a clone is a population derived by asexual reproduction from a single ancestor) have the same genotype.
D. yeast cells mutate under the influence of certain substrates.
E. under a variety of conditions, a constant genome can be insured (viz., by eliminating external nitrogen).

Items 488 - 493 are concerned with the schematic diagram of a plant. Items 488 - 490 refer to the small letters on the diagram. Items 491 - 493 refer to capital letters on the diagram.

488. (2.20) Where will a pollen tube begin to form?

489. (2.20) Where is the tissue that greatly expands the plant's absorptive surface?

490. (2.20) Identify the point at which maturation of eggs has occurred.

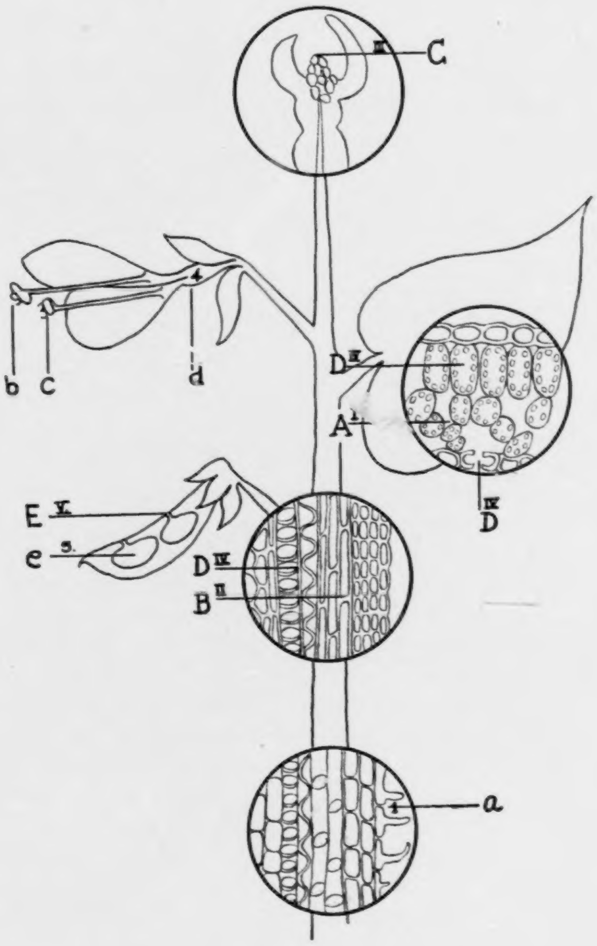
491. (2.20) Where is a reserve supply of air maintained?

492. (2.20) Identify the tissue mainly responsible for the transportation of organic foods.

493. (2.20) Where does meristem tissue predominate?

494. (3.00) If differentiation consists solely in the "restriction of the manifold potentialities of an originally totipotent egg," then the individual cell in a late embyro would be expected to contain, on the average,

A. more kinds of plasmagenes per cell than the zygote.
B. fewer kinds of plasmagenes per cell than did the zygote.



C. as many kinds of plasmagenes per cell as did the zygote.
D. either as many or more kinds of plasmagenes per cell as did the zygote.
E. either more or fewer kinds of plasmagenes per cell as did the zygote, since this kind of differentiation holds no necessary implication as to numbers of kinds of plasmagenes per cell.

495. (3.00) If differentiation consists solely in the "orderly widening of the potentialities of an initially nullipotent egg," then, in all the cells of a late embryo taken together there should be

A. more kinds of plasmagenes than in the zygote.
B. fewer kinds of plasmagenes than in the zygote.
C. as many kinds of plasmagenes as in the zygote.
D. either as many or more kinds of plasmagenes as in the zygote.
E. either more or fewer kinds of plasmagenes as in the zygote, since this kind of differentiation holds no necessary implication as to the numbers of kinds of plasmagenes.

496. (2.20) Ephrassi uses yeast as an experimental material in attempting to answer a question about differentiation in multicellular organisms since

A. a clone of yeast cells presents the same degree of specialization of parts as does a multicellular organism.
B. the process of cell division is essentially the same in all organisms.
C. in yeast, "differentiated" cells can reproduce sexually.
D. genetic mutation affecting metabolic processes occurs more readily in yeasts than in multicellular organisms.

E. transplantation of nuclei between cells are more readily performed on yeasts than on higher organisms.

The following key applies to questions 497 - 500.

Three chicken eggs, "X," "Y," "Z," each weighing 50 grams, were placed in an incubator for 10 days at a temperature of 40°C. At the end of this time egg "X" weighed 50 grams; egg "Y" weighed 42 grams; and egg "Z" weighed 48 grams.

KEY

A. Egg "X." **B.** Egg "Y." **C.** Egg "Z."
D. None of the eggs. **E.** All of the eggs.

497. (3.00) Which consumed the greater amount of oxygen?

498. (3.00) Which of the eggs contained the most active embryo?

499. (3.00) In which of the eggs was there no respiration?

500. (3.00) Which of the eggs did not contain a living embryo?

501. (3.00) A female collie dog gave birth to five puppies. One of the puppies remained enveloped in the amnionic membrane after birth and several hours later was dead even though it had lived and developed within this same membranous sac for many weeks prior to birth.

Locate the most crucial problem pertinent to this situation.

- **A.** How does circulation after birth differ from circulation in the embryo?
- **B.** How does the embryo get its food?
- **C.** How does embryonic respiration differ from respiration in the puppy after birth?
- **D.** How does the puppy's disease resistance compare to disease resistance in the embyro stage?
- **E.** How does discharge of excretory waste products in the embryo differ from excretion in the puppy after birth?

502. (3.00) In the older chick embryo, the blood containing the highest concentration of oxygen is that in the

A. pulmonary veins.
B. pulmonary arteries. **C.** aorta.
D. artery leading to the membranes nearest the shell.
E. veins leading from the membranes nearest the shell.

503. (3.00) In the fetal pig, the blood containing the highest concentration of oxygen is that in the

A. pulmonary veins. **B.** pulmonary arteries.
C. aorta. **D.** artery leading to the placenta.
E. veins leading from the placenta.

504. (3.00) In humans, twins are sometimes identical and sometimes not. In either case, for twins to be produced, one *invariable* condition is that

- **A.** the fertilized egg be compressed before it becomes implanted in the uterus.
- **B.** two eggs be fertilized at the same time.
- **C.** there be two organizers.
- **D.** the egg divide into two at the first cleavage.
- **E.** one egg be fertilized simultaneously by two sperms.

"The origin of the primitive organs is intimately connected with that of the germinal layers. The first differentiation of the segmented ovum results in the cells of the embryo becoming arranged as two layers, an outer one known as the epiblast and an inner one known as the hypoblast. The outer of these forms a primitive sensory organ, and the inner a primitive digestive organ."

"Descriptive Embryology Comes of Age" by Francis M. Balfour, in *A Source Book in Animal Biology.*

In the above excerpt are some of the important and basic concepts concerning the embryology of an animal. The following items relate to the interpretation of this excerpt which was first published in 1880. After each statement number on the answer sheet, blacken space

- *A* if the statement is true and its truth is supported by evidence given in the quotation.
- *B* if the statement is true, but its truth is not supported by evidence given in the quotation.
- *C* if the statement is false and its falsity is supported by evidence given in the quotation.
- *D* if the statement is false, but its falsity is not supported by evidence given in the quotation.

505. (4.20) The excerpt describes the formation of the mesoderm.

506. (4.20) The various organs are derived from the germ layers.

507. (4.20) The epithelium, endorderm, and mesoderm are the three germ layers from which all organs arise.

508. (4.20) The "segmented ovum" is the zygote undergoing mitotic division.

509. (4.20) The mitotic division resulting in the "segmented ovum" is called maturation.

510. (4.20) The mitotic division of the zygote first results in the formation of a ball of cells.

511. (4.20) The cells comprising the solid ball of cells undergo further division and rearrangement to form a blastula.

512. (4.20) The blastula is a structure comprised of an outer cell layer and an inner cell layer.

513. (4.20) The outer cell layer gives rise to the nervous system.

514. (4.20) The inner cell layer, the endoderm, gives rise to the lining of the digestive tract.

"The ovarian rhythm culminating periodically in ovulation is accompanied by rhythmic changes in the uterus and vagina and, in lower animals, in the intensity of the sex urge. . . . In this cycle, periodically the uterine lining becomes thicker and softer, more vascular and glandular. The height of proliferation, vascularity, and secretion is reached a few days after ovulation and represents a periodic adaptation of the uterus for the reception of the embryo."

"If fertilization and implantation of the embryo into the uterine wall fail to occur, the uterine lining, in lower mammals, gradually subsides to its previous less vascular condition, with some sloughing-off of the uterine lining. In some primates, including man, the sloughing-off is accompanied by moderate hemorrhage."

Carlson, A. J. and Johnson, V. *The Machinery of the Body.* Copyright 1937, University of Chicago. By permission.

Items 515 - 525. For each item number, blacken space

- **A** if the item is true and its truth is supported by information given in the paragraphs.
- **B** if the item is true, but its truth is not supported by information given in the paragraphs.

C if the item is false and its falsity is supported by information given in the paragraphs.

D if the item is false but its falsity is not supported by information given in the paragraphs.

515. (4.20) The menstrual cycle in human beings is controlled by the secretion of at least 4 hormones, 2 from the pituitary gland and 2 from the ovaries.

516. (4.20) A few days after the rupture of the follicle, the uterus is best adapted for the reception of the embryo.

517. (4.20) The corpus luteum (yellow body) forms from the cells of the ruptured follicle.

518. (4.20) If fertilization fails to occur, the yellow body persists.

519. (4.20) Changes occurring in the uterus take place independently of those in the ovary.

520. (4.20) Follicle-stimulating hormone from the pituitary acts in the early part of the cycle by stimulating active cell division in patches of germinal epithelium of the ovary.

521. (4.20) Soon after ovulation, a hormone secreted by the follicle, exerts control.

522. (4.20) Estrogen, produced in the follicle, initiates the glandular development in the lining of the uterus.

523. (4.20) In lower animals the period of intense sex drives or heat is coordinated with the ovarian cycle.

524. (4.20) A hormone from the pituitary gland stimulates the formation of follicles within the ovary.

525. (4.20) During pregnancy, the secretion of the yellow body acts as a check on the pituitary gland.

526. (4.20) In validating or disproving Weismann's theory of development, the crucial conclusion from partially constructed amphibian eggs is that

- **A.** the first cleavage plane bears no relation to the axis of the future embryo.
- **B.** altering the orientation of the cleavage planes does not prevent the formation of a normal embryo.
- **C.** after five cell divisions, any resulting nucleus contains the potentialities for forming a whole embryo.
- **D.** after five cell divisions, no single nucleus contains the potentialities for forming a whole embryo.
- **E.** the division of cytoplasm rather than nucleus determines whether one or two whole embryos are formed.

527. (2.30) In order for one half of the constricted egg to receive only $\frac{1}{16}$ of the zygote nucleus, the cleavage which must have sent a nucleus into the non-nucleated portion is the

A. second. **B.** third. **C.** fourth.
D. eighth. **E.** sixteenth.

528. (2.20) A piece which would normally produce medullary plate can be interchanged in the early gastrula with a piece which would normally produce epidermis, and yet the resultant embryo is normal. This by itself implies that

- **A.** these two pieces were already differentiated before their exchange.
- **B.** these two pieces were already determined before their exchange.
- **C.** the development of these two pieces was dependent on their position in the embryo.
- **D.** only a small portion of the early gastrula is already determined.
- **E.** the cells in the two pieces were identical at the time of transplantation.

529. (4.20) The finding that some parts of the late blastula or early gastrula are interchangeable is important to the development of the concept of "organizer" in embryology inasmuch as

- **A.** the organization evident in the later embryo is not the result of self-differentiation of every part in the blastula, hence must be accomplished by factors acting during gastrulation.
- **B.** the number of possible tissues which can be formed by a small portion of the blastula is increased as the development proceeds.
- **C.** the nuclei of all the cells in the blastula are produced by mitotic divisions and hence are all alike, so that the cytoplasms of all the cells in the blastula are also identical.
- **D.** the nuclei of all the cells in the blastula are produced by mitotic divisions, so all differentiation up to the end of cleavage is cytoplasmic.

530. (2.20) Spemann and Mangold use heteroplastic transplantations (i.e., between two species) in their experiments primarily in order to

- **A.** mark the position and orientation in the donor of the piece of tissue whose organizing capacity are being tested.
- **B.** distinguish the primary from the secondary embryo.
- **C.** distinguish between the products of "self-differentiation" and of "induction" in the secondary embryo.
- **D.** utilize the phenomenon of hybrid vigor in producing a large and distinct secondary embryo.
- **E.** insure that the implanted piece is ahead of the host tissue in its degree of determination.

531. (2.10) As used by Spemann and Mangold, "determination" signifies

- **A.** the capacity to produce a given type of tissue, such as brain, notochord, epidermis, or somite.
- **B.** the capacity to produce a tissue distinctive of the species to which it belongs.
- **C.** visible differentiation between cell types or cell masses.
- **D.** the ability to produce several different types of tissues, depending on immediate environment.
- **E.** the ability to produce the type of tissue characteristic of the site of origin, regardless of environment.

532. (4.20) The test of whether the organization center is subdivided into parts *with different fates* already determined at the onset of gastrulation is to

- **A.** compare the results of implanting pieces from earlier and later gastrulae.
- **B.** compare the results of implanting pieces from the median and lateral dorsal blastopore lip of an early gastrula.
- **C.** orient the implanted piece so its axis is at right angles to the host's.
- **D.** implant a piece into a host which has finished gastrulation.
- **E.** mash the piece from the dorsal lip of the blastopore before implanting it.

533. If the inducing action of the implant takes place after
(2.20) it has invaginated, then

A. one tissue or organ may conceivably be the cause of the determination of another tissue.
B. only physical factors—stretching, contiguity with fluid or with other cells—determine the course of development of individual cells.
C. only chemical factors which act at the cell surface determine the course of development of individual cells.
D. the most fruitful analysis of induction agents is apt to be in terms of specific stimulants to the carbohydrate metabolic enzymes.
E. the only problem left for embryologists is to discover how the organizing capacity comes to be localized in the region of the dorsal blastopore lip.

534. Which of the following examples would Spemann con-
(2.20) sider *not* to be a case of induction?

A. The formation of somite from host as well as implanted tissue in a secondary embryo.
B. The formation of medullary plate from host as well as implanted tissue in a secondary embryo.
C. The formation of medullary plate from host tissue alone in a secondary embryo.
D. The formation of notochord solely from implanted tissue in a secondary embryo.
E. The presence of a gut cavity belonging to a secondary embyro.

535. The fact that in secondary embryos neural tissue is
(4.20) formed of presumptive epidermis is

A. predictable on the basis of Weismann's theory.
B. compatible with Weismann's theory, though not demanded by it.
C. contrary to expectation on the basis of Weismann's theory.

536. The essentials of an experiment designed to answer
(4.20) Lewis' question "Will the lens arise from the ectoderm without the contact of the optic vesicle on the skin?"

A. Leaving the optic vesicle intact, replace the overlying epidermis with other epidermis.
B. Transplant the optic vesicle to a new region of the embryo.
C. Destroy the portion of the neural plate which gives rise to optic vesicle.
D. Bring the optic vesicle into contact with different epidermis.
E. Prevent contact of optic vesicle with the uninjured epidermis which normally yields lens.

537. The embryos killed two or three days after the opera-
(4.20) tion are useful for Lewis' purpose insofar as they establish, better than do the older embryos,

A. the prospective lens-like character of the masses of cells induced by the optic vesicles.
B. the epidermal origin of the induced lenses.
C. the structural relationship between the optic cup and the brain.
D. the fact that small optic cups can regenerate from the stubs left after optic vesicle removal.
E. the self-differentiating capacity of the optic vesicle at the time of its removal.

538. The embryos killed a week or more after the operation
(4.20) are useful for Lewis' purposes insofar as they establish, better than do the younger embryos,

A. the prospective lens-like character of the masses of cells induced by the optic vesicles.
B. the epidermal origin of the induced lenses.
C. the structural relationship between the optic cup and the brain.
D. the fact that small optic cups can regenerate from the stubs left after optic vesicle removal.
E. the self-differentiating capacity of the optic vesicle at the time of its removal.

539. A hypothetical finding which would prove most em-
(4.20) barrassing to Lewis' conclusion that a lens forms from epidermis only after contact with the optic vesicle would be

A. the failure of a lens to form from epidermis in contact with a transplanted optic vesicle.
B. the failure of a lens to form from abdominal epidermis in contact with a normally situated, normally sized optic vesicle.
C. a lens in its normal position when the optic vesicle has been removed early and not regenerated.
D. a lens in its normal position in contact with a small regenerated optic cup.
E. the failure of a lens to form from epidermis in contact for a long enough period of time with a small regenerated optic cup.

Item 540 deleted.

541. The experiments of both Spemann and Lewis are de-
(4.20) signed to analyze the processes of embryonic development in terms of

A. what are the structural parts of the embryo at a given stage.
B. the chemical and physical properties of the inducing agents.
C. how supernumerary structures can be caused.
D. the physical relations of the parts of the embryo to each other and to the whole.
E. whether some tissues are responsible for the determination of other tissues.

542. The eyelessness in Chase's anophthalmic strain of mice
(2.20) is due to

A. genetic differences between it and the control C57 Black strain.
B. lack of use of the eyes in the evolutionary history of the species.
C. experimental procedures resulting in a systemic poisoning of the embryos at a critical age.
D. malnutrition of the embryos at a critical age due to physiological deficiencies in the mother.

543. In view of Chase's findings, it would appear that the
(2.20) critical stage in eye development in his anophthalmic strain of mice is during

A. optic vesicle determination in the neural plate stage.
B. the optic vesicle growth to reach the epidermis.
C. the formation of bone in the skull adjacent to the eye.
D. the formation of pigment in the outer layer of the optic cup.
E. the differentiation of the seven layers of the retina.

Chase states that: "In an embryological study of a variable character, there is a handicap in not knowing what the adult condition of any particular embryo would have been."

544. The variability of character to which Chase refers is
(2.10) the

A. variability in rates of development of embryos in the same litter.
B. variable time interval during which mating could have occurred.
C. variability in the size of the optic vesicles at different stages in development.
D. difference in frequency of eyelessness between adults of the anophthalmic and the control strains.
E. occurrence of eyes of different sizes, as well as eyelessness, in adults of both the anophthalmic and control strains.

545. The aspect of Chase's method of study of the character
(4.20) which made its variability a handicap is that

A. in order to observe the character at a particular embryonic stage, the embryo had to be killed.
B. the only distinction between the anophthalmic and control series of embryos was genetic.
C. Chase's method of brother-sister inbreeding encourages genetic segregation, with concomitant phenotypic variability.
D. Chase's data are reported as measurements in units small enough for small variations to be noticeable.
E. sections of the embryo were photographed rather than drawn, so that minor variations in the results presented are more obvious.

546. The precaution which Chase considers must be taken
(4.20) to overcome this handicap is to

A. use strains which are less inbred.
B. take greater care to avoid disturbing the embryos while observing them.
C. observe several embryos of each strain at each stage.
D. make the environmental conditions of the embryos as uniform as possible.
E. test the tentative conclusions based on observation alone by surgical experiments of the type performed by Lewis.

547. The main problem addressed by Ten Cate and Van
(2.20) Doorenmaalen may best be stated as

A. What is the most sensitive test for the presence of the specific lens substance?
B. What is the chemical means by which one organ induces the formation of another organ?
C. What is the chemical means by which the nuclear genes act to determine the characters of the differentiated organs?
D. Is the adult lens-specific substance present in any organs of the embryo other than lens or presumptive lens?
E. When do specific adult substances first appear in development?

548. One condition which must be met if a substance is to be
(4.20) considered as "lens-determining" is that it be present

A. in the cells which give rise to lens prior to their thickening into the lens-plate.
B. in the cells of the optic vesicle which come into contact with the epidermis.
C. in greater quantity in the completely differentiated lens than in the invaginated lens.
D. in the adult body, only in the lens.
E. in the adult lens.

549. From a barely positive reaction, Ten Cate and Van
(4.20) Doorenmaalen conclude that the adult lens-specific substances are present in invaginating lenses before their complete separation from the epidermis. The circumstance which permits this conclusion to be drawn is that

A. no tissue other than lens was present in the extract tested for antigenicity.
B. no tissue other than lens reacts at all with the antiserum.
C. all chick embryos at the same incubation age are at exactly the same stage in development.
D. morphologically, presumptive lens cannot be distinguished from other epidermis before lens invagination.
E. the same lens antigens are present in vertebrates as far apart in evolutionary history as frogs and chicks.

550. Ten Cate and Van Doorenmaalen consider that the
(2.20) lack of reaction of presumptive lens tissue prior to its invagination

A. indicates that the lens-determining substance is not chemically identical with the adult lens-specific substance.
B. indicates that the lens-forming substance is not chemically identical with the lens-determining substance.
C. is due to a lack of adult lens antigens in the embryo before lens-invagination.
D. is due to the presence of the lens antigens in the optic vesicle, rather than in the presumptive lens tissue, before lens-invagination.
E. may be the result of an insufficient sensitivity of their technique.

Directions: Below are three propositions about living organisms. Each can be defended or rejected on the basis of evidence presented in course readings and the outside reading for this examination. (5.10)

EITHER write two separate essays in which you present the relevant evidence and argument for and/or against *two* of these three propositions. Each essay should require 30 minutes for thought, organization and writing.

OR, write one essay in which you present the relevant evidence and arguments weighing for and against *one* of these three propositions.

If you write one essay instead of two, it should be the product of thought, organization and writing requiring 60 minutes. One 60-minute essay, if well presented, will receive as much credit as two less complete 30-minute essays.

Write your essays in the blank pages of this booklet, labelling each with the letter of the proposition with which it is concerned.

Proposition A: The pattern of cell differentiation and organ-formation is under the control of nuclear genes whose action is conditioned by the inherited organization of the cytoplasm.

Proposition B: Chemical differentiation precedes morphological differentiation in development, which presupposes the action of different enzyme systems in different cells, so that the primary problem to be tackled jointly by genetics and embryology is: which enzyme systems are involved in the differentiation of a given tissue, and how are these different enzymes activated or set up?

Proposition C: The mechanism of evolution must be explained in terms of changing genes.

ESSAY QUESTION: Make a diagram of the process of oogenesis; label as fully as you can. (5.20)

22. *Heredity—*
In Plants, Animals and Mankind

HEREDITY—IN PLANTS, ANIMALS, AND MANKIND

1. The principle of segregation and heterozygous pairs of
(1.10) unit characters was first discovered by

A. Linnaeus. **B.** Gregor Mendel.
C. Thomas Hunt Morgan. **D.** Sir Francis Galton.
E. Charles Darwin.

2. The units in chromosomes responsible for the inheritance
(1.10) of various unit characteristics are the

A. nuclei. **B.** vacuoles. **C.** asters. **D.** nodes.
E. genes.

3. If a human being inherits two x-chromosomes it is likely
(1.10) that this individual will be

A. a female. **B.** a male. **C.** color blind.
D. sterile. **E.** none of the above.

4. A disease characterized by red blood corpuscle dis-
(1.10) integration is known as

A. hemophilia. **B.** anemia. **C.** erythroblastosis.
D. leucocytosis. **E.** syphilis.

5. The process whereby the number of chromosomes is
(1.10) reduced to half in the germ cells is

A. ovulation. **B.** mutation. **C.** myiasis.
D. mitosis. **E.** meiosis.

6. A mutation may be defined as the
(1.10)

A. modification of a structure by use or disuse.
B. gradual change of an organ or structure through selection of favorable variations of the fluctuating type.
C. sudden appearance of a new trait which breeds true.
D. sudden appearance of a new characteristic which is due to environmental changes.

Items 7 - 11. In man sex is determined according to the XX-XY formula. In all there are 24 pairs of chromosomes in each ordinary somatic cell of every human being. The following classes of cells are present in relation to chromosome numbers.

A. 24 pairs including XX. **B.** 24 pairs including XY.
C. chromosomes including X.
D. 24 chromosomes including X or Y.

To which of the above four groups would each of the following cells belong?

7. Mature sperm. **8.** Mature ovum.
(1.10) (1.10)

9. Fertilized egg which is to develop into a male.
(1.10)

10. Fertilized egg which is to develop into a female.
(1.10)

11. Second polar body.
(1.10)

12. A plant with a constant character is operationally de-
(1.10) fined by Mendel as one in which

A. all its gametes are the same.
B. none of its gametes are hybrid.
C. all the offspring produced by crossing it to a hybrid are constant.
D. there is true breeding regardless of genotype, i.e., hybrids produce only hybrids, dominants only dominants, etc.
E. all offspring produced by self-fertilization are identical to the parent.

13. A dominant character is operationally defined by Mendel
(1.10) as

A. the character which dominates the recessive.
B. the character which is not lost in a cross between dominant and recessive.
C. the appearance of the parent which breeds true.
D. the parental character which appears in three-fourths of the hybrids, i.e., F_1.
E. the parental character which appears in all the hybrids, i.e., F_1.

14. When the hybrid is self-fertilized, Mendel finds that in
(1.10) the F_2

A. ¾ look like the hybrid and ¼ look like the recessive grandparent.
B. ¼ look like the dominant grandparent, ¼ look like the recessive grandparent, and ½ take on a new appearance.
C. ¾ look like ¾ of the hybrids, while ¼ look like the other ¼ of the hybrids.
D. ¾ look like half the hybrids, ¼ look like the other half.

15. The notations A, Aa, and a, are introduced by Mendel
(1.10) to represent

A. three kinds of gametes.
B. three kinds of appearances.
C. three kinds of breeding behavior as well as three appearances.
D. three kinds of appearances, two of which have the same gametes.
E. three kinds of breeding behavior, two of which have the same appearance.

16. When a plant which is hybrid in two characters, AaBb,
(1.10) is self-fertilized, Mendel finds that (select *all* correct alternatives)

A. in the first character ¾ are dominant and ¼ recessive.
B. in the second character ¾ are dominant and ¼ recessive.
C. $(\frac{3}{4})^2$ are dominant in both characters.
D. $(\frac{1}{4})^2$ are recessive in both characters.
E. $2(\frac{3}{4})(\frac{1}{4})$ have one dominant and one recessive character.

17. If the two characters are independent of each other, the
(1.20) expression which would describe the offspring of a self-fertilized dihybrid AaBb is

A. $(\frac{1}{2}D + \frac{1}{2}R)^2$ where ½D means the probability of a dominant is ½ and similarly ½R means the probability of recessive is ½.
B. $(\frac{3}{4}D + \frac{1}{4}R)^2$ where ¾D means the probability of a dominant is ¾ and similarly ¼R means the probability of a recessive is ¼.
C. $(\frac{1}{2}A + \frac{1}{2}a)^2$ where ½ is gene frequency of A.
D. $(\frac{3}{4}A + \frac{1}{4}a)^2$ where ¾ is gene frequency of A.

18. In his explanation of his results, Mendel postulates that
(1.20) all of the gametes of the constant dominant parent, AA, are alike because,

A. when AA is crossed with aa, the result is Aa.
B. gametes must be identical to the individual who produces them.
C. any combination of two gametes will then be the same, i.e., AA.
D. all gametes receive $\frac{1}{2}$ of their mother cell's nucleus and in this case both halves are the same.
E. all of the gametes appeared the same, so Mendel gave them one name.

19. Mendel was then able to postulate that the hetero-
(1.20) zygous form had two kinds of gametes, "A" and "a" because

A. the heterozygous when self-fertilized produces two genotypes, A and a.
B. the heterozygous when self-fertilized produces two kinds of constant forms, AA and aa.
C. the heterozygous when self-fertilized produces two phenotypes, dominant and recessive.
D. the F_1 hybrid is produced by a union of "A" and "a" and so it is natural that when it produces gametes they should also be "A" and "a."
E. each gamete receives $\frac{1}{2}$ of the mother cell's nucleus and $\frac{1}{2}$Aa is either A or a.

20. Mendel postulates that the hybrid (the F_1 generation)
(1.20) produces "A" and "a" gametes *in equal numbers* because

A. for every "A" gamete produced, an "a" must also be produced.
B. for every AA individual produced by the hybrid, an aa is also produced.
C. the maternal contribution to the hybrid is equal to the paternal contribution.
D. the law of probability applies, since each pair of differentiating characters is inherited independently.
E. if the probability of "A" equals the probability of "a" equals $\frac{1}{2}$, then the probability for their union is $(\frac{1}{2}A + \frac{1}{2}a)^2$ which coincides with the empirical finding.

21. Write your answer in the space provided on each line.
(1.20)

A plant whose genotype is AaBbCc is crossed with a plant whose genotype is AAbbCc. Below is a list of gene combinations or individuals. You are to write as a fraction, when possible, the probability of getting each gene combination or individual in the offspring generation produced by the above stated cross.

A. AA__________ B. CC__________
C. bbCC__________ D. AABBCC__________
E. AAbbCC__________ F. AaBbCc__________
G. a constant breeding individual__________

22. Sutton's observation constituted cytological confirmation
(1.10) of Mendel's theory of hereditary units. Sutton argued that there was a correspondence between Mendel's units and the behavior of

A. genes. **B.** chromosomes. **C.** nuclei.
D. germ cells.

23. The Mendelian conclusion which is *most directly* con-
(1.10) firmed by cytology is

A. individuals which look alike may breed differently.
B. the constant form produces only one kind of gamete.
C. each character is inherited independently of other characters.
D. the hybrid produces as many kinds of gametes as there are constant combinations.
E. for each character the hybrid's gametes contain either the paternal or maternal contribution but never both.

24. The Mendelian conclusion which Sutton argues must
(1.10) be an exception rather than the general rule is that

A. individuals which look alike may breed differently.
B. the constant form produces only one kind of gamete.
C. each character is inherited independently of other characters.
D. the hybrid produces as many kinds of gametes as there are constant combinations.
E. for each character the hybrid's gametes contain either the paternal or maternal contribution but never both.

25. Sutton states that the primordial germ cell contains two
(1.20) equivalent chromosome series, a maternal set and a paternal set. In the reduction division, if all of the maternal chromosomes were on one side of the equatorial plane, the following Mendelian conclusions would be directly contradicted by cytology: (select *all* correct alternatives)

A. The hybrid produces each kind of gamete on the average in equal numbers.
B. Each character is inherited independently of other characters.
C. The hybrid produces as many kinds of gametes as there are constant combinations.
D. The constant form produces only one kind of gamete.
E. For each character the hybrid's gametes contain either the paternal or maternal contribution but never both.

26. The probability that a gamete will contain any given
(1.20) chromosome is (let n be the number of chromosomes in a set)

A. $\frac{1}{2}$. **B.** $\frac{1}{n}$. **C.** $\frac{1}{2n}$. **D.** $(\frac{1}{2})^n$.
E. indeterminate.

27. Combining cytological and breeding data, the probabil-
(1.20) ity that a gamete will contain any given *set* of chromosomes is

A. $\frac{1}{2}$. **B.** $\frac{1}{n}$. **C.** $\frac{1}{2n}$. **D.** $(\frac{1}{2})^n$.
E. none of the above would hold for all sets, i.e., the probability would be different for different combinations of maternal and paternal chromosomes.

28. This last conclusion is a restatement of the Mendelian
(1.10) conclusion that

A. the hybrid produces each kind of gamete on the average in equal numbers.
B. the constant form produces only one kind of gamete.
C. each character is inherited independently of other characters.
D. the hybrid produces as many kinds of gametes as there are constant combinations.
E. for each character the hybrid's gametes contain either the paternal or maternal contribution but never both.

29. East shows in his investigations that a continuous char-
(1.10) acter might be made up of a series of independent Mendelian factors if it is assumed that (select *all* correct alternatives)

A. there is no dominance.
B. there can be no hybrid or heterozygous individuals.
C. each gene which adds a unit of the character has an allele which adds nothing.
D. the effects of all the genes determining the character are additive.
E. there are numerous alleles of each gene which interact in such a way that each combination of two yields a different degree of the character.

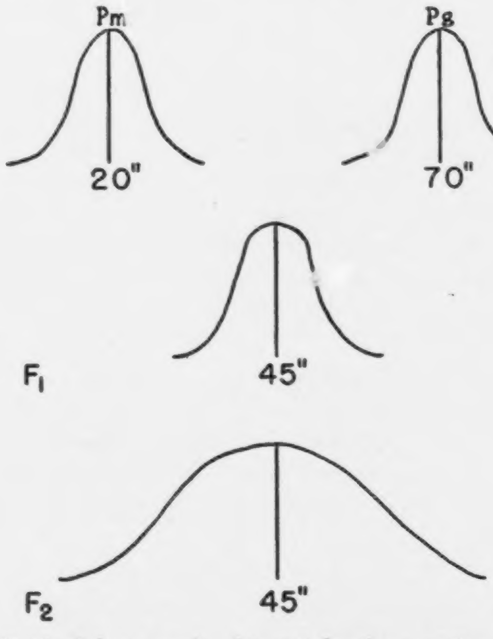
30. With these assumptions it follows that, *due to genetic*
(1.20) *variability*, the characters will be distributed as a normal probability curve in (select the *two* best alternatives)

A. an F_1 population produced by crossing members of two diverse inbred races.
B. an F_2 population produced by selfing a member of the F_1 described in alternative A.
C. any population which has been inbred for many generations.
D. any randomly breeding population.
E. any randomly breeding population where $q = (1 - q)$ for each of the factors.

31. The reason for your answer is that in both cases (see
(1.20) item 30)

A. the distribution of the character is represented by the expansion of the binomial $(a + b)^{2n}$ where n is the number of factors that determine it.
B. the grades of character, i.e., phenotypes, will be randomly distributed in the sense that the occurrence of any one phenotype is a matter of chance.
C. the probability of any one genotype is equal to the probability of any other genotype which equals $(\frac{1}{2})^n$ where n is the number of factors.
D. the probability of any gene combining with any other is the product of their separate probabilities.
E. there are many genotypes which will have the same phenotype.

For questions 32 - 37, refer to the figures below:



One individual from each of two inbred races Pm and Pg constitute the parents of the F_1. The F_2 generation is produced by the self-fertilization of a 45" individual of the F_1.

32. According to East's hypothesis, the variability of the F_1
(1.10) approximates the variability of the parental races because

A. all variation in the 3 populations is the result of fluctuation.
B. all of the genotypes in each of the 3 populations have the same phenotype.
C. all 3 populations are homozygous in all factors which determine the character.

33. The reason for your answer is that
(1.20)

A. inbreeding leads to homozygosity, and homozygous individuals produce only one kind of gamete.
B. inbreeding leads to homozygosity, and you cannot obtain heterozygotes by crossing homozygotes.
C. AABBccdd, aabbCCDD, and AaBcCcDd all have the same phenotype.
D. fluctuation is variability due to differential effects of the environment and is not inherited.

34. A second deduction from the reasoning in item 33 is
(1.20) that a 35" F_1 and a 55" F_1 will produce F_2 generations that have

A. the same mean and same variability.
B. different means and different variabilities.
C. the same mean and different variabilities.
D. different means and the same variability.

35. The variation in F_2 is greater than F_1 because in F_2
(1.20)

A. every genotype has a different phenotype.
B. there is more heterozygosity.
C. all possible gene combinations are represented.

36. According to East's hypothesis, one can also deduce
(1.10) that some F_2 individuals might be more extreme than any member of the grandparental races (Pm and Pg) if

A. the F_2 contained a large number of individuals.
B. not too many factors differentiated one grandparental strain from the other.
C. both grandparents possessed genes which added units and genes which did not add units.

37. The import of East's experimental conclusions for Gal-
(1.20) ton's theory of inheritance can be summarized as follows:

A. East showed that an extreme deviant is almost as likely to produce a type like itself as is a slight deviant, thereby disproving Galton's theory of regression.
B. East proved that the modal class contains the largest number of genotypes, i.e., there is actually less chance of these individuals breeding true than more extreme individuals, thereby upsetting Galton's notion that average parents have offspring like themselves.
C. East showed that by selecting extreme individuals for only a few generations, it was possible to produce two separate extreme populations from one continuous intermediate population—which confirms plural segregating factors as an explanation of size inheritance and is incompatible with any other theory of size inheritance.
D. East showed that variations in continuous characters can be inherited, and therefore provided the theoretical basis for a natural selection theory of evolution. Galton's theory is based on the assumption that populations remain the same from generation to gen-

eration; as a consequence, his theory provides no ground upon which selection could operate.

E. East's conclusions cannot be directly compared to Galton's as East used inbred populations for his breeding experiments, while Galton's theory applies only to random breeding populations.

38. (1.10) The number of chromosomes in the zygote of the human is

A. 12. **B.** 24. **C.** 36. **D.** 48. **E.** 96.

39. (1.10) The number of chromosomes in a mature human gamete is

A. 12. **B.** 24. **C.** 36. **D.** 48. **E.** 96.

40. (1.10) The number of chromosomes in a somatic cell of the human is

A. 12. **B.** 24. **C.** 36. **D.** 48. **E.** 96.

41. (1.10) The hereditary traits which a human being will possess is determined by his

A. phenotype. **B.** pedigree. **C.** environment.
D. genotype. **E.** somatoplasm.

42. (1.10) Mitosis

A. reduces the number of chromosomes in a somatic cell.
B. doubles the number of chromosomes in the germ cell.
C. gives rise to two somatic cells (cells other than germ cells), each with one half the normal chromosome number.
D. gives rise to two somatic cells, each with double the normal chromosome number.
E. gives rise to two cells with no change in the chromosome number.

For each of items 43 - 45 select the appropriate word from the key list:

KEY

A. mitosis. **B.** inbreeding. **C.** dominance.
D. hybridization. **E.** conjugation.

43. (1.10) Breeding of closely related parents.

44. (1.10) Breeding of parents differing in hereditary characteristics.

45. (1.10) Appearance of one of two mutually exclusive characteristics when both are potentially present.

46. (1.10) Pairs of genes which influence the same characters and are found in the same location in homologous chromosomes are called

A. alleles. **B.** phenotypes. **C.** genotypes.
D p[illegible]types. **E.** paratypes.

47. (1.10) The first scientist to execute controlled experiments in heredity:

A. Galton. **B.** Aristotle. **C.** DeVries.
D. Mendel. **E.** Wallace.

48. (1.10) A color-blind boy inherits the trait from

A. male parent. **B.** female parent.
C. maternal grandparents.
D. paternal grandparents. **E.** remote ancestors.

49. (1.10) Having the double number of chromosomes (diploid):

A. Spermatozoa. **B.** Spermatid.
C. Spermatogonia. **D.** Egg. **E.** Zygote.

50. (1.10) The man considered to be the father of modern taxonomy is

A. Aristotle. **B.** Cuvier. **C.** Linnaeus.
D. Darwin. **E.** Plato.

51. (1.10) The diploid generation in life cycle of oak trees

A. bryophyte. **B.** gametophyte. **C.** thallophyte.
D. sporophyte. **E.** saprophyte.

True or False.

52. (1.10) Average I.Q. in the United States is increasing with each generation.

True or False.

53. (1.10) Comparative length of life causes difficulty in studying human heredity.

54. (1.10) The unit determiner of a hereditary trait:

A. gemmule. **B.** gonad. **C.** ganglion.
D. glomerulus. **E.** gene.

55. (1.10) Hair cells would have a number of chromosomes called

A. haploid. **B.** diploid. **C.** triploid.
D. quadraploid. **E.** octaploid.

56. (1.10) Sex is determined during reproduction at the time of

A. oocyte formation. **B.** zygote formation.
C. meiotic divisions. **D.** mitotic divisions.
E. ovulation.

57. (1.10) Which of the following statements best describes a chromosome?

A. The term chromosome is synonymous with the term gene.
B. It is a theoretical unit concerned with inheritance.
C. It is a sub-microscopic unit found in the nucleus of all animal cells.
D. It is the material bearer of the hereditary particles.
E. It is a phase observed during mitosis.

58. (1.10) Mutations are

A. changes that take place in the genes and chromosomes that affect heredity.
B. changes that take place in the body of an individual through use and disuse.
C. always big changes, such as development of a white individual in a race of black ones.

59. (1.10) Mutations

A. occur spontaneously but cannot be produced artificially.
B. can be produced artificially by the use of X-rays.
C. can be produced artificially by the action of almost any physical or chemical agent on the cell.

60. (1.10) Lethal genes are

A. heredity determiners which produce death in interaction with the environment.
B. found only in the human male because of the nature of the Y-chromosome.
C. found only in certain weak and defective individuals.

61. (1.10) Mendel

A. developed the first workable theory of evolution.
B. was the first to work out and apply the basic principles of scientific method.
C. worked out some of the basic laws of heredity by experimenting with garden peas.

62. (1.10) The laws of heredity are

A. the only scientific laws which are related to the law of probability.
B. typical scientific laws generally in that they are related to the law of probability.
C. only related to the law of probability in cases where they can be expressed as normal or bell curves.

63. (1.10) Multiple factor heredity (more than two pairs of heredity characteristics on separate pairs of chromosomes) without dominance is responsible for

A. determination of eye color.
B. determination of general mental ability.
C. determination of albinism.

64. (1.10) With a single pair of contrasting characteristics, the second generation of a hybrid cross (with dominance) produces a

A. 1 : 2 : 1 ratio. **B.** 3 : 1 ratio.
C. 9 : 3 : 3 : 1 ratio.

65. (1.10) With two pairs of contrasting characteristics on separate pairs of chromosomes, the second generation of a hybrid cross (with dominance) produces a

A. 9 : 3 : 3 : 1 ratio.
B. 1 : 2 : 1 ratio. **C.** 1 : 1 ratio.

66. (1.10) The chromosome number is reduced in connection with the formation of sperms and ova because

A. otherwise the number would be doubled with each generation.
B. hereditary characteristics can be produced normally with only half the usual chromosome number.
C. only half the chromosomes carry genes for determining heredity.

67. (1.20) The basis of every trait which is inherited, as were Mendel's pea plant characters, is

A. a self-reproducing entity in every cell of the adult organism.
B. a pair of self-reproducing entities in every cell of the embryo.
C. a pair of self-reproducing entities in the nucleus of every gamete.
D. an enzyme in the cytoplasm of every cell of the adult organism.
E. an enzyme in the cytoplasm of every gamete.

68. (1.20) Diversity or variation in the plant kingdom is enhanced by

A. self-pollination. **B.** cross-pollination.
C. vegetative reproduction. **D.** double fertilization.
E. spore reproduction.

69. (1.20) Chromosomes are present in pairs in the somatic cells of animals. What is their origin?

A. one pair from each parent.
B. all may have come from one parent.
C. an equal number from each parent.
D. one member of each pair from each parent.

70. (1.20) From the viewpoint of heredity what is the most important thing about mitosis?

A. each daughter cell receives the same number of chromosomes.
B. each daughter cell receives the same kind and number as possessed by the parent cell.
C. each daughter cell receives the same kind of chromosomes.
D. the cytoplasm is divided equally.

71. (1.20) The genes in the human germ cells

A. may be changed markedly by practices indulged in by the individual during his lifetime. As an example, constant athletic practice on the part of the parent would make the offspring more athletic than otherwise.
B. may be markedly modified by changes in climate, such as generally would be encountered in moving to different sections of the United States.
C. may be markedly altered by mechanical manipulation of the chromosomes of the sex cells in the laboratory by the use of fine needles so that the resulting individual's characteristics may be controlled.
D. may be markedly modified by the effects of an atomic bomb explosion.
E. cannot be altered or changed by any process under the control of man.

72. (1.20) Which of the following is the most inclusive statement about the origin of genes and enzymes that is warranted on the basis of present knowledge?

A. Enzymes are self-perpetuating while genes are not.
B. Enzymes give rise to genes.
C. Genes give rise to enzymes.
D. Genes give rise to enzymes and other genes as well.
E. Enzymes give rise to genes and more enzyme material as well.

73. (1.20) Which one of the following statements best applies to sex determination in man?

A. Maleness is produced by the Y sex-chromosome.
B. Maleness is produced by the X sex-chromosome.
C. Maleness is produced by the autosome when two X-chromosomes come together in the same zygote.
D. Maleness is produced by the autosomes if two Y-chromosomes come together in the same zygote.
E. Maleness is produced by the autosomes if one X- and one Y-chromosome come together in the same zygote.

74. (1.20) The hereditary factors which an individual inherits are determined by his

A. environment. **B.** genotype. **C.** progeny.
D. cytoplasm. **E.** ecological adjustment.

75. (1.20) Which one of the following statements has proved to be scientifically acceptable?

A. The superior mental, moral, and physical traits of blue-bloods are transmitted via the blood stream to their descendants.
B. By royal blood is meant that members of royal families generally carry superior traits which are passed on in the blood, generation after generation.
C. Certain criminals and ne'er do-wells have inherited tainted blood and are likely to pass this on to their offspring.

- **D.** If blood from a different race is used in giving a transfusion the individual receiving the transfusion may acquire some of the donor's physical or mental characteristics.
- **E.** The vehicle of heredity operates independently of the blood.

76. (1.20) The life processes which establish the hereditary nature of a new individual occur

- **A.** immediately upon fertilization of an egg cell by the sperm.
- **B.** when the fertilized egg cell is safely implanted within the wall of the uterus.
- **C.** when the embryo heart first starts beating.
- **D.** when the umbilical cord is cut and tied.
- **E.** when the attending physician first observes functioning of the breathing reflex.

77. (1.20) If your parents or grandparents completed their formal education before 1900 the best reason they were not taught the Mendelian Laws was that

- **A.** religious pressure discouraged the teaching of this material prior to the twentieth century.
- **B.** Mendel had not yet completed his research.
- **C.** Mendel's laws lacked justification prior to 1900.
- **D.** medieval attitudes toward science prevented adequate spreading of the reports of such research.
- **E.** the paper reporting this research was overlooked for fifty years.

78. (1.20) The inheritance of hair color in humans is a good illustration of how

- **A.** the gene theory cannot be applied to human heredity.
- **B.** environmental conditions experienced by our ancestors complicate genetic explanations of acquired characteristics.
- **C.** chromosomal aberrations often follow exposure to short-wave radiation.
- **D.** characteristics may be transmitted by a parent not possessing the characteristic only to offspring of the sex opposite to the parent.
- **E.** the action of a gene may be modified by the presence of another corresponding gene.

Items 79 - 83.

KEY

- **A.** Genes are transmitted as unit characters producing their effects within narrow ranges of environmental variation.
- **B.** Plant and animal body cells cannot change their chromosome content.
- **C.** Epistasis. **D.** Heterosis.
- **E.** The theory of inheritance of acquired characters.

79. (1.20) Whales and dolphins superficially resemble fish more closely than they do their biological relatives, the mammals.

80. (1.20) It is possible for offspring ranging from pure black to pure white to be born to first-generation mulatto parents.

81. (1.20) A gardener, desiring to raise larger beans, saved only the very largest of the year's crop for seed. Beans grown from this seed averaged no larger than the total crop harvested the previous year.

82. (1.20) It is possible for a yellow apple twig to be grafted to a red apple tree and still produce yellow apples if growing conditions remain balanced.

83. (1.20) Orchardists do not allow seedlings to grow to maturity but prefer to graft a cutting to the rootstock of the seedling.

84. (1.20) The inheritance of hair color in man illustrates

- **A.** that there is no possibility of accounting for the inheritance of certain traits.
- **B.** how environmental conditions experienced by our ancestors complicate genetic explanations of acquired characteristics.
- **C.** how chromosomal aberrations often follow exposure to short-wave radiation.
- **D.** how characteristics may be transmitted by a parent not possessing the characteristic only to offspring of the sex opposite to that of the parent.
- **E.** that the action of a gene may be modified by the presence of another corresponding gene.

For items 85 - 90 select from the following key the most appropriate response.

KEY

A. Mitosis. **B.** Meiosis. **C.** Both. **D.** Neither.

85. (1.20) Body or somatic cells multiply by this (these) method(s).

86. (1.20) The daughter cells resulting from this (these) process(es) always have twice the diploid number of chromosomes.

87. (1.20) Chromosomes move to opposite sides of the cell.

88. (1.20) The process always begins when a sperm nucleus enters the egg cytoplasm and ends when the zygote has been produced.

89. (1.20) The daughter cells contain only one-half as many chromosomes as the mother cell.

90. (1.20) The immediate daughter cells resulting from the process are gametes.

91. (1.20) There are 48 chromosomes in the unmatured sex cell of a given species. How many chromosomes would probably be in the matured sex cell of this species?

A. 12. **B.** 16. **C.** 24. **D.** 64. **E.** 96.

92. (1.20) If there are 16 chromosomes in each somatic cell of a certain species of animal, how many chromosomes will there be in an egg cell produced by this animal?

A. 1. **B.** 2. **C.** 32. **D.** 8. **E.** 16.

Items 93 - 96 involve characteristics of genes and chromosomes. The statement in each case may pertain to genes, chromosomes, both or neither. For each item select the appropriate key category.

KEY

A. Genes. **B.** Chromosomes. **D.** Both. **D.** Neither.

93. (1.20) Only one member of each pair goes into one gamete.

94. (1.20) They become part of the nuclear membrane after cell division.

95. (1.20) A reduction in number by one-half occurs during meiosis.

96. (1.20) X-ray exposure may result in the appearance of a single new trait without altering any other traits.

Items 97 - 102 involves characteristics of hereditary traits. The statement in each case may pertain to a dominant trait, a recessive trait, to both dominant and recessive, or to neither. For each item select the appropriate key category.

KEY

A. Dominant. **B.** Recessive. **C.** Both. **D.** Neither.

97. (1.20) The gametes carry the same number of genes for the trait as does the zygote.

98. (1.20) An individual having the trait may be either homozygous or heterozygous.

99. (1.20) Neither parent has the trait, yet some of the offspring do.

100. (1.20) Transmission from one generation to another is accomplished by genes carried in the gametes.

101. (1.20) In a given family the trait never skips a generation, then reappears in the next succeeding generation.

102. (1.20) An individual who has the trait is always heterozygous.

103. (1.20) During the first half of the 20th century the application of new knowledge about the mechanisms of heredity has resulted in

A. substantiation of the earlier views about race and race differentiation in human beings.
B. the revelation that there was not much new to be learned about human racial differences.
C. the inference that there is no such thing as the human race.
D. radical changes in the way in which human races and human racial differences are regarded.
E. None of the above.

104. (1.20) The behavior of chromosomes and hereditary factors is similar in which of the following respects?

A. They occur in pairs.
B. The alleles segregate when the reproductive cells are formed.
C. Recombination occurs at fertilization.
D. Two of the above. **E.** All of the above.

105. (1.20) Which of the following statements about crossing over is most acceptable?

A. There are as many crossing-over possibilities as there are genes in any given individual's cells.
B. The farther apart two genes lie on the chromosome the greater the likelihood of their crossing over.
C. All genes are capable of producing detectible changes in the organism as a result of crossing over.
D. Genes that are linearly adjacent on a chromosome have the greatest cross-over potential.
E. None of the above is acceptable.

106. (1.20) Which of the following would provide the most information regarding the genotype of an individual or a characteristic?

A. The individual shows the dominant characteristic.
B. All the males of a generation show the dominant characteristic.
C. The individual shows a blending of two distinct phases of the characteristic.
D. The individual produced offspring all of which showed the dominant characteristic.
E. The individual when mated with an individual showing the dominant characteristic produced ten offspring all of which showed the dominant characteristic.

107. (1.20) It has been found that all epileptics have an abnormal type of brain wave. It has also been found that

A. in some cases only one parent may show this abnormal condition.
B. in some cases both parents may show this same type of brain wave.
C. in all cases at least one parent shows this type of brain wave.
D. only two of the above are true.
E. all of the above are true.

108. (1.20) As a result of mitosis the daughter cells have, when compared to the parent cell,

A. double the number of chromosomes with the same kind of chromosomes and the same kind of genes.
B. one half the original number of chromosomes with the same kind of chromosomes and the same kind of genes.
C. one half the original number of chromosomes and each cell has one half the original kind of chromosomes and one half the original kind of genes.
D. the same number and the same kind of chromosomes and the same kind of genes.
E. double the number of chromosomes with one half the original kind of genes.

109. (1.20) The final number of chromosomes in a matured gamete is

A. double that present in a somatic cell, and the set of chromosomes includes but one member from each homologous pair that was present in the unmatured cell.
B. one half that present in a somatic cell, and the set of chromosomes includes both members (now fused as one) from each homologous pair that was present in the unmatured cell.
C. the same as that present in a somatic cell and the set of chromosomes includes one half of both members from each homologous pair that was present in the unmatured cell.
D. one half that present in a somatic cell, and the set of chromosomes includes but one member from each homologous pair that was present in the unmatured cell.
E. double that present in a somatic cell, and the set of chromosomes includes one half of both members from each homologous pair that was present in the unmatured cell.

110. (1.20) Inbreeding tends to produce

A. genetically pure individuals.
B. larger than normal sized offspring.
C. heterozygous offspring.
D. increased strength and vigor in the progeny.
E. greater diversity of traits in the offspring.

111. (1.20) In man the sex of an individual of the genotype XY is determined primarily by genes located on

A. X-chromosome. **B.** Y-chromosome.
C. autosomes. **D.** sex chromosomes.
E. none of the above.

112. One significant aspect of maturation is the fact that
(1.20)

A. the number of chromosomes in the germ cells is doubled.
B. the number of chromosomes in the germ cells is reduced by one half.
C. it accomplishes cross-fertilization.
D. it allows additional chromosomes to be added to the chromosomal complement.
E. it is characteristic only of higher animals.

113. In the human species the number of boys being born
(1.20) exceeds that of girls by 4 to 6 percent. A reason would be that

A. Y-chromosome-bearing sperms fertilize more eggs than those sperms containing the X-chromosome.
B. since female embryos are weaker more female embryos are aborted.
C. more Y-chromosome-bearing sperms mature.
D. men, in general, are stronger than women.
E. more couples desire male offspring and follow practices that directly or indirectly increase the number of male babies born.

114. A pedigreed breed of horses is established by
(1.20)

A. mating an animal of one species with one of another species.
B. keeping a record of the animals' ancestry.
C. breeding horses from good stock.
D. raising only pure strain animals.
E. inbreeding highly select animals for a number of generations, then registering the breed's characteristics.

115. The body cells of a plant or animal producing gametes
(1.20) with 14 chromosomes will contain

A. one fourth as many chromosomes.
B. one half as many chromosomes.
C. the same number of chromosomes.
D. twice as many chromosomes.
E. four times as many chromosomes.

116. Identical twins have many similar characteristics be-
(1.20) cause

A. the two eggs from which they developed contained exactly the same number of chromosomes.
B. they were exposed to the same prenatal environment.
C. they represent two individuals born at the same time of the same parents.
D. they arose from two blastomeres of the same zygote.

117. Which one of the following is most likely to be true?
(1.20)

A. The 1 : 2 : 1 ratio in the F_2 generation of a monohybrid cross involving dominance is the *phenotypic* ratio.
B. Both allelic genes for a certain trait normally occur in the same gamete.
C. In the dihybrid cross involving dominance, the number of phenotypes in the F_2 generation exceeds the number of genotypes.
D. The 9 : 3 : 3 : 1 ratio in F_2 generation of a dihybrid cross involving dominance is the *genotypic* ratio.
E. Allelic genes normally become separated in reduction division.

118. Domesticated animals, if placed in the wild and no
(1.20) longer cared for, will

A. continue to live without evolutionary change, if they are able to survive.
B. revert gradually through evolutionary change to a form somewhat characteristic of their remote ancestors, if they are able to survive.
C. become more specialized along the directions taken in domestication, if they are able to survive.
D. all die.
E. usually all survive, taking one of the courses of evolution described in responses **B** and **C.**

Items 119 - 133. Assume only one pair of alleles (genes) to be operating to produce the character. Blacken space

A if the item refers to a character due to autosomal dominant genes.
B if the item refers to a character due to autosomal recessive genes.
C if the item refers to a character due to sex-linked dominant genes.
D if the item refers to a character due to sex-linked recessive genes.
E if the item refers to a character due to more than one of the above types of genes.

119. All daughters possess the character if the father pos-
(1.20) sesses it.

120. Possessed by fifty per cent of the sons of heterozygous
(1.20) mothers.

121. Possessed by all of the sons of mothers possessing it.
(1.20)

122. Found in all of the offspring if the father is homozygous.
(1.20)

123. Occurs in both men and women but more often in men.
(1.20)

124. Found in all of the offspring if the mother is homozy-
(1.20) gous.

125. May occur in both sons and daughters even though
(1.20) neither parent possesses the character.

126. A character that is expected in three-fourths of the off-
(1.20) spring although only one parent is heterozygous.

127. Will be found in all of the offspring if either parent
(1.20) is homozygous.

128. A daughter may receive a gene for this character from
(1.20) her father even though he does not have the character.

129. The mother must have the character for the son to
(1.20) have it.

Item 130 deleted.

131. The father must have the character for the daughter
(1.20) to have it.

132. Found in all of the sons of homozygous mothers.
(1.20)

133. Occurs in both men and women, but more often in
(1.20) women.

134. Which of the following best describes what is meant by
(1.20) *eugenics?*

A. The science having to do with the betterment of living conditions to secure more efficient human beings.

B. A sense of well-being and buoyancy which is the outcome of hygienic living.
C. Race improvement by fostering better heredity.
D. Hybrid vigor which results from crossing two inbred strains.
E. Well-being and happiness resulting from having a well-integrated personality.

135. (1.20) A cell having the haploid number of chromosomes

A. has undergone reduction-division.
B. contains twice the normal number of chromosomes.
C. contains only autosomes.
D. contains only sex-chromosomes.
E. has not undergone reduction-division.

136. (1.20) The behavior of chromosomes and hereditary factors is similar in which of the following respects?

A. They occur in pairs.
B. The alleles segregate when the reproductive cells are formed.
C. Recombination occurs at fertilization.
D. Two of the above. **E.** All of the above.

137. (1.20) Which one of the following is an expected result of inbreeding?

A. The offspring tend to become more and more homozygous.
B. The young will show a greater diversity of traits than the parents.
C. The progeny will tend to possess greater strength and vigor than the previous generation.
D. The offspring will tend to be more heterozygous than the parents.
E. Each succeeding generation will tend to be somewhat larger than the previous one, both as to numbers and in physical size and weight of individuals.

138. (1.20) Two pairs of characters are said to be *completely* linked when

A. they are due to the same pair of alleles.
B. they do not assort at random.
C. only the same phenotypic combinations are found in the F_1 as in the parental types.
D. each combination in the parents is inherited as if it were a single Mendelian factor.
E. they are due to genes at the same loci on homologous chromosomes.

139. (1.20) Independent segregation of genes occurs when

A. gametes are formed by a homozygous organism.
B. gametes are formed by an organism heterozygous for one pair of genes.
C. gametes are formed by an organism heterozygous for more than one pair of genes.
D. gametes are fertilized, at least one parent being heterozygous for one pair of genes.
E. gametes are fertilized, at least one parent being heterozygous for more than one pair of genes.

140. (1.20) In any cross between two pure-breeding strains differing only in a single character, the F_1 generation is always

A. distributed in a 3 to 1 ratio between dominant and recessive phenotypes.
B. exactly like one of the parental strains.
C. more vigorous than either parental strain.
D. like the maternal parent.
E. uniform when either sex is considered by itself.

141. (1.20) The proper sequence is

A. resting cell, prophase, metaphase, anaphase, telophase.
B. resting cell, metaphase, prophase, anaphase, telophase.
C. resting cell, prophase, anaphase, metaphase, telophase.
D. resting cell, metaphase, prophase, telophase, anaphase.
E. resting cell, prophase, telophase, metaphase, anaphase.

142. (1.20) Which one of the following statements concerning inbreeding with selection of desirable traits is correct?

A. It tends to make the breeding stock more vigorous.
B. It almost invariably increases resistance to infectious disease.
C. It tends to obscure recessive traits since recessive genes never have the opportunity to pair with others like themselves in the process of inbreeding.
D. It tends to produce a more homozygous strain.
E. Fertility is increased by inbreeding.

143. (1.20) If a fruit fly inherits one X and one Y chromosome it is likely that this individual will

A. have vestigial wings. **B.** be sterile.
C. be a male. **D.** be color blind.
E. be a super female.

144. (1.20) The principles of genetics can be used in the solution of many types of problems. Four of the following are such types of problems. Which one is least related to the field of genetics?

A. What is the underlying basis for race prejudice?
B. How does an organism come to be of the particular sex that it is?
C. Why can some race horses outrun others?
D. How did the earth come to be as it is today?
E. Why do some people become insane?

145. (1.20) Which of the following genetic factors make it exceedingly difficult to eliminate feeblemindedness from the population?

A. Since all feebleminded individuals are heterozygous it is unpredictable what genes they will transmit to their offspring.
B. Feeblemindedness is a recessive trait.
C. Feebleminded people always raise large families.
D. Feeblemindedness is caused by gene mutation.
E. Feeblemindedness is a dominant trait.

146. (1.20) All the best-known genetic mechanisms for sex determination have what feature in common?

A. One member of a specific chromosome pair is functionally or physically missing.
B. One member of a particular gene pair is missing in the males in the Drosophila type of mechanism, and in the females in the poultry type.
C. The Y chromosome never contains any active genes in males.
D. Two types of eggs are always produced, but only one type of sperm.
E. Male and female zygotes always have the same number of chromosomes.

147. (1.20) Y represents yellow, which is dominant. y represents green, which is recessive. YY is crossed with yy. Which of the following statements concerning the offspring (first generation) is true?

- **A.** All of them will be yellow.
- **B.** All of them will be green.
- **C.** Three will be yellow and one will be green.
- **D.** Three will be green and one will be yellow.
- **E.** Two will be yellow and two will be green.

148. (1.20) When there is lack of dominance between a gene and its allele (opposite) which of the following is true?

- **A.** There are more phenotypes than genotypes.
- **B.** The heterozygous individual is intermediate in respect to the two extreme aspects of the trait in question.
- **C.** A mating between two heterozygous individuals is likely to produce a maximum of two different phenotypes.
- **D.** A mating between two heterozygous individuals is likely to produce a maximum of two different genotypes.
- **E.** None of the above is true.

149. (1.20) If in a large number of generations, factors tend to be inherited as a group, rather than to be inherited separately, they are said to be

A. linked. **B.** sex-linked. **C.** sex-influenced.
D. sister-factors. **E.** segregated.

150. (1.20) A single mating between two homozygous animals

- **A.** must result in heterozygous offspring only.
- **B.** must result in homozygous offspring only.
- **C.** must result in both homozygous and heterozygous offspring.
- **D.** must result either in homozygous offspring only or in heterozygous offspring only.

Items 151 - 155. Each item may be referred to one of the following terms, used in dealing with inheritance:

A. complementary factor. **B.** dominant factor.
C. lethal factor. **D.** multiple factors.
E. supplementary factors.

151. (1.20) An individual heterozygous for black and white is always black among guinea pigs.

152. (1.20) In certain yellow mice, any yellow male crossed to any yellow female produces ⅔ yellow to ⅓ non-yellow, instead of the ¾ to ¼ ratio expected from the mating of two heterozygous individuals.

153. (1.20) When certain strains of white sweetpeas are crossed their offspring have colored flowers.

154. (1.20) In some crosses of red wheat with white a simple ratio of 3 to 1 is found in F_2; in others a ratio of 15 to 1 is found in F_2. Some of the F_2 reds are as dark as the red grandparent; some are about the same shade as the F_1, and some are as pale as the white grandparent.

155. (1.20) When the fundamental factor for single comb in poultry is modified by a certain factor (p), the comb of the offspring becomes pea comb; when modified by a different factor (R) it becomes rose comb, and when modified by both factors simultaneously the young develop a type of comb known as walnut.

156. (1.20) In fertilization the fusion of greatest hereditary significance occurs between the

A. yolk materials. **B.** cytoplasm. **C.** nuclei.
D. centrosomes. **E.** chromoplasts.

157. (1.20) Chromosomes are present in pairs in the somatic cells of animals. What is their origin?

- **A.** one pair from each parent.
- **B.** all may have come from one parent.
- **C.** an equal number from each parent.
- **D.** one member of each pair from each parent.

158. (1.20) Some species of animals are capable of reproducing by parthenogenesis. If it is true, why would a parthenogenetic species, not known to be such, be misleading if it should be used in genetic studies involving attempted crosses?

- **A.** In parthenogenetic reproduction, the parents contribute unequal amounts of chromatin material.
- **B.** In parthenogenetic reproduction, individual offspring are all of the male sex.
- **C.** In parthenogenetic reproduction, all of the hereditary contribution is made from one parent.
- **D.** Parthenogenetic reproduction is not suitable for genetic studies because it is reproduction by fission.
- **E.** Parthenogenetic reproduction could be used with satisfactory results in genetic studies involving experimental crossing.

159. (1.20) A test of the urine for a certain individual reveals that phenylpyruvic acid is present in his urine. From this it can be inferred that the individual is

A. diabetic. **B.** feebleminded. **C.** schizophrenic.
D. an alcoholic. **E.** a fairly normal individual.

Item 160 deleted.

161. (1.20) A human zygote differs from a human gamete in that a human zygote

- **A.** will always contain at least one X-chromosome while all gametes will not.
- **B.** does not possess the genetic factor in pairs.
- **C.** has the haploid or n number of chromosomes.
- **D.** will divide by meiosis.
- **E.** results from the division of a gamete.

Item 162 deleted.

163. (1.20) Which of the following might account for the appearance of the first seedless orange?

A. Inbreeding. **B.** Self-pollination.
C. Natural selection. **D.** Hybridization.
E. Mutation.

164. (1.20) Mendelian inheritance assumes which one of the following conditions to be true?

- **A.** Every gamete is pure, that is, contains only one member of a given pair of factors.
- **B.** Every gamete is hybrid, that is, contains both members of a given pair of factors.
- **C.** In the formation of a gamete there is a doubling of the amount of genetic material carried.

D. Genes for a given pair of factors fuse or blend in the organism during each generation and thus lose their identity.
E. Characteristics produced by genes are not subject to modification by environmental influences.

165. (1.20) Which one of the following would constitute an application of the progeny test?

A. The offspring (progeny) of a certain dog cross are checked periodically from birth to adulthood to observe the order of appearance of inherited traits.
B. An orchardist cross-pollinates Jonathan and Baldwin apple blossoms in an attempt to obtain an apple combining some of the good qualities of both these varieties.
C. The desirable traits of a young race horse are compared with those traits known to have been characteristic of the horse's ancestors listed in its pedigree.
D. A rabbit breeder back-crosses a recessive young rabbit with one of its parents, whose genotype is unknown, to determine whether the parent is homozygous or heterozygous for the trait in question.
E. All weaklings from the progeny of a certain poultry cross are culled out and only the best are used for subsequent breeding purposes.

166. (1.20) Albinism is an abnormal condition

A. the gene for which is never inherited through the mother from the grandfather.
B. which appears only in every other generation.
C. caused by the lack of genes for normal pigmentation.
D. which is sex-linked.
E. caused by the lack of vitamin E.

167. (1.20) A heterozygous genotype is represented by which one of the following?

A. TtRr. **B.** TTrr. **C.** ttrr. **D.** Tr.
E. None of these.

168. (1.20) According to the theory of Bridges, sex determination in Drosophila is achieved by

A. the presence or absence of a Y-chromosome.
B. the number of X-chromosomes per somatic cell.
C. the ratio of X-chromosomes to autosomes.
D. the ratio of Y-chromosomes to autosomes.
E. the ratio of X-chromosomes to Y-chromosomes.

169. (1.20) When a cross-over is said to have occurred, the *observation* this interpretation is intended to explain is that

A. a combination of linked characters in the F_1 is unlike either combination in the homozygous parent.
B. a new combination of linked characters appears in the offspring of a backcross of hybrid to the double homozygous recessive.
C. genetic material is transferred from one chromosome to another.
D. all of the above. **E.** none of the above.

170. (1.20) The chromosomal distinction between linked and independent pairs of characters is in terms of

A. whether the genes for the two pairs of characters are on homologous or nonhomologous chromosomes.
B. whether it is exhibited in a backcross or an F_2 generation.
C. the degree of intertwining during synapsis.
D. whether the primary germ cells (gonia) are diploid or haploid.
E. whether the genes are arranged in the same order on the two chromosomes.

171. (1.20) When two pairs of alternative characters are said to be inherited independently of each other, the *observations* this interpretation is intended to explain are that

A. the ratios of the combinations of characters from any cross are such as can be predicted by multiplying the ratios expected for one pair of characters by the ratios expected for the other.
B. the ratios for each pair of characters, considered alone, are the same as would be obtained if no other character had been involved in the cross.
C. the two pairs of characters are caused by alleles at different loci on homologous chromosomes.
D. the two pairs of characters are influenced by gene-pairs on two different chromosomes.
E. the one pair of characters affects a part of the organism quite distinct from the part affected by the other pair of characters.

172. (1.20) Bobbing the tails of bulldog puppies does not eliminate the necessity for continuing this procedure in succeeding generations because

A. no gene change is produced by bobbing the tail.
B. nature intended the tail to be long.
C. the tail is a vestigial structure.
D. tail bobbing is merely a fad.
E. the germ plasm has no effect on the somatoplasm.

173. (1.20) The characteristics of an individual are

A. dependent principally on heredity.
B. dependent principally on environment.
C. dependent on the interaction of heredity and environment.

174. (1.20) Genes are believed to act

A. through the agency of enzymes.
B. through some unknown agent or life source.
C. through an increase in the rate of molecular activity within cells.

175. (1.20) Sex-linked lethal genes are believed to be responsible for

A. the small number of offspring of most human marriages.
B. the generally shorter life expectancy of men as compared to women.
C. the generally smaller physical stature of women as compared to men.

176. (1.20) The greater number of male fertilizations as compared to female fertilizations in humans at the beginning of embryonic life is believed to be due to

A. the fact that the male-producing sperm lacks a part of a chromosome, making it smaller.
B. the fact that the male throughout life is more vigorous and active than the female.
C. the fact that the female egg and the male-producing sperm are opposites, and opposites attract one another.

177. (1.20) The possibility of hereditary variation is greatest when

A. self-fertilization occurs as in some plants.
B. an abundant food supply is provided for the egg.

C. gametes from inbred organisms unite.
D. organisms reproduce sexually.
E. organisms reproduce asexually.

178. (1.20) The human female has two X- or sex chromosomes whereas the male has one X- and one Y-chromosome. Equal numbers of boys and girls are expected because the parents produce

A. one kind of egg and sperm.
B. one kind of egg and two kinds of sperm.
C. two kinds of egg and one kind of sperm.
D. two kinds of eggs and sperms.
E. several kinds of eggs and sperms.

179. (1.20) Sex-linked characteristics tend to

A. descend from grandfathers to grandsons through mothers who carry them but do not show them.
B. descend directly from mother to daughter.
C. be found principally in women.

180. (1.20) Sex-linked inheritance involves characteristics which are

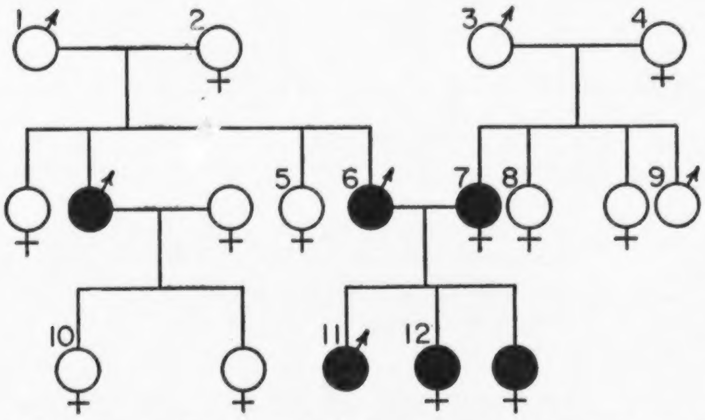
A. found only in males who are defective.
B. carried in the lower portion of the X-chromosome which is unpaired in the male.
C. always lethal in males.

181. (1.20) The law of probability

A. is always expressible in the form of a normal curve.
B. is always synonymous with pure chance.
C. may include the effect of patterning or warping factors.

Items 182 - 190.

Below is a pedigree of deafness in which the individuals afflicted by this condition are shown by black circles; normal individuals are indicated in white. Usual symbols for male and female are used. On the basis of the pedigree, answer the exercises which follow it. After each exercise number on the answer sheet, blacken the *one* lettered space which designates the correct answer.



182. (2.20) The condition of deafness shown in the pedigree is inherited as

A. a dominant autosomal characteristic.
B. a recessive autosomal characteristic.
C. an incomplete dominant.
D. a sex-linked recessive characteristic.
E. a sex-linked dominant characteristic.

183. (2.20) All of the information required to answer item 182 above can be found in

A. mating of 1 and 2. **B.** mating of 3 and 4.
C. mating of 6 and 7.
D. mating of 1 and 2 plus 3 and 4.
E. mating of 3 and 4 plus 6 and 7.

184. (2.20) Individual #1 in the pedigree is

A. homozygous normal. **B.** heterozygous normal.
C. homozygous recessive. **D.** heterozygous recessive.
E. undetermined due to insufficient evidence.

185. (2.20) Individuals #6 and #7 are both

A. homozygous recessive. **B.** homozygous dominant.
C. heterozygous dominant.
D. undetermined since evidence offered by the pedigree is insufficient.

186. (2.20) Individual #8 is

A. undoubtedly homozygous normal.
B. probably homozygous normal.
C. undoubtedly heterozygous normal.
D. probably heterozygous normal.
E. undetermined since pedigree does not offer sufficient evidence.

187. (2.20) The probability for individual #9 to be homozygous is

A. the same as for the heterozygous condition.
B. one chance out of three.
C. three chances out of four.
D. one hundred per cent. **E.** zero.

188. (2.20) Individual #10 can contribute

A. no gene for the recessive condition to any of his children.
B. a recessive gene to each of his children.
C. the gene for the normal condition to three out of four of his children.
D. the gene for the normal condition to one half of his children.
E. no gene for the normal condition to any of his children.

189. (2.20) Individual #11 will contribute the gene for deafness to

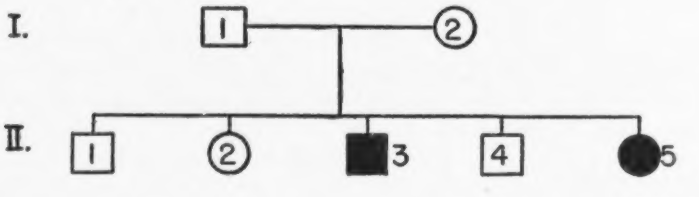
A. all his children. **B.** none of his children.
C. only his sons. **D.** only his daughters.
E. one half of his daughters and one half of his sons.

190. (2.20) The probability for individual #5 to be heterozygous is

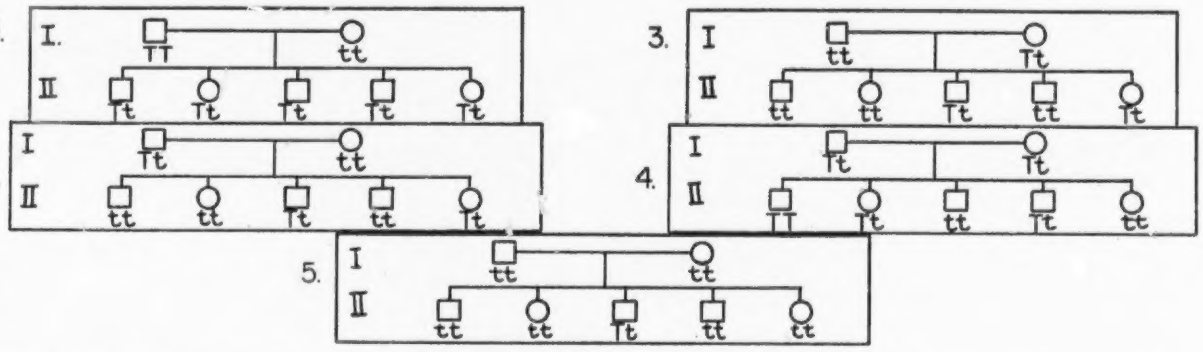
A. none at all. **B.** two chances out of every three.
C. two chances out of every four.
D. three chances out of every four.
E. one hundred per cent.

In a family history, squares are used to represent males while circles represent females. The Roman numerals indicate the generation. The following family history for a certain trait shows the father (I–1), the mother (I–2), and their five children (II–1-5).

A black square or circle designates an individual who has the trait; a white square or circle an individual who does not have the trait.



191. (2.20) For the trait represented by the black square and circle (page 216), "T" indicates DOMINANT and "t" RECESSIVE, which one of the five solutions below shows the manner in which this trait is passed on from parents to children?



192. (2.20) According to Waddington, the role of genes in differentiation is as follows:

- **A.** Changes in genome determine the direction which will be taken by groups of cells at an early stage of development.
- **B.** Changes in the cytoplasm depend on the outcome of enzyme interaction, and are therefore independent of genes.
- **C.** At different stages of development different genes are active in the sense of releasing gene products into the cytoplasm.
- **D.** At different stages of development different genes are active in the sense that different syntheses, initiated and controlled by genes, are taking place.
- **E.** Genes compete with each other directly for control of the metabolic activities of the cytoplasm, the outcome of the competition depending on which genes have the greatest capacity for self-duplication.

193. (2.20) According to Spiegelman, the role of genes in differentiation is as follows:

- **A.** Changes in genome determine the direction which will be taken by groups of cells at an early stage of development.
- **B.** Changes in the cytoplasm depend on the outcome of enzyme interaction, and are therefore independent of genes.
- **C.** At different stages of development different genes are active in the sense of releasing gene products into the cytoplasm.
- **D.** At different stages of development different genes are active in the sense that different syntheses, initiated and controlled by genes, are taking place.
- **E.** Genes compete with each other directly for control of the metabolic activities of the cytoplasm, the outcome of the competition depending on which genes have the greatest capacity for self-duplication.

194. (2.20) The cytoplasmic self-duplication elements postulated by both Waddington and Spiegelman differ from nuclear genes in their

- **A.** chemical constitution: cytoplasmic "genes" are probably non-protein, whereas nuclear genes are nucleoprotein.
- **B.** role in the cell: cytoplasmic "genes" are the basis for growth and differentiation, whereas nuclear genes are responsible only for heredity.
- **C.** stability: cytoplasimc "genes" are not able to persist as of a given type for an indefinitely long number of cell generations.
- **D.** rate and mode of reproduction: nuclear genes do not reproduce at a geometric rate.
- **E.** synthesizing capacity: nuclear genes are unable to synthesize protein.

195. (2.20) The postulated difference between nuclear and plasmic "genes" (stated in the correct answer to item 194) is made necessary because of the fact that

- **A.** non-Mendelian heredity is rarely observed.
- **B.** no cytoplasmic protein has been isolated.
- **C.** the synthesis of protein requires energy in the form of phosphate bonds.
- **D.** each nuclear gene divides in two during mitosis.
- **E.** there is no evidence that nuclear genes are involved in growth.

196. (2.20) The phenomenon of enzyme adaptation is significant for the problem of gene action, since it proves that

- **A.** the gene is not necessary for the production of an enzyme.
- **B.** the gene is not the sole condition for the formation of an enzyme.
- **C.** the gene can be modified by the presence or absence of substrates.
- **D.** differentiation involves a modification of cytoplasmic enzyme systems.
- **E.** there must be genes in the cytoplasm.

197. (2.20) In genetic experiments with yeast, the haploid cells correspond chromosomally to

- **A.** the zygotes of multicellular animals.
- **B.** the ectodermal derivatives in multicellular animals.
- **C.** the endodermal derivatives in multicellular animals.
- **D.** the mesodermal derivatives in multicellular animals.
- **E.** the gametes of multicellular animals.

198. (2.20) Whether a genetic trait is dominant or recessive to its alternative in yeast is best discovered from observing the phenotype of

- **A.** a hybrid haploid cell. **B.** a hybrid diploid cell.
- **C.** a hybrid haploid or diploid cell with equal ease.
- **D.** neither a haploid nor a diploid cell, since neither can be hybrid.
- **E.** neither a haploid nor a diploid cell, since neither is a whole organism.

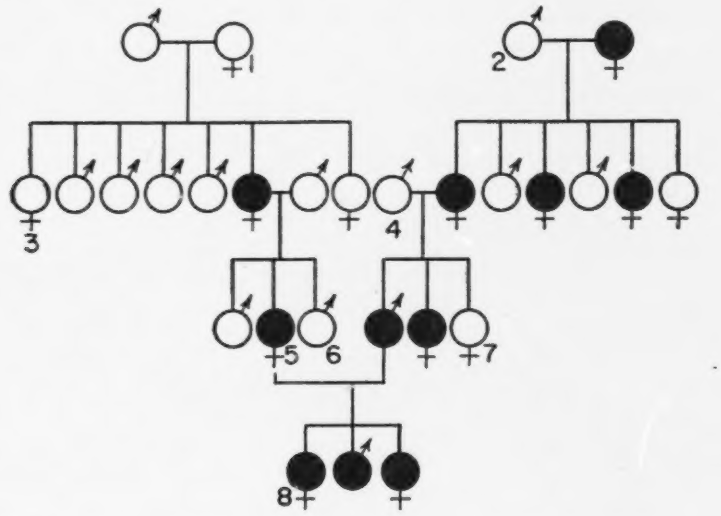
199. (3.00) If a pair of alternative characters in yeast is due to a single pair of alleles, the proportion of ascospores bearing the dominant character produced by a hybrid yeast cell should be

A. 100%. **B.** 75%. **C.** 66⅔%. **D.** 50%. **E.** 25%.

200. (2.20) The aspect of Baltzer's findings in hybridizing sea-urchins of different species that supports the theory that the chromosomes are the bearers of heredity is that

A. whether a hybrid resembles one parent or both depends on the ratio of maternal to paternal chromosomes.
B. hybrids obtained from reciprocal crosses are not the same.
C. the hybrids do not develop to maturity unless both maternal and paternal chromosomes are compatible with the egg cytoplasm.
D. the effects of chromosomes on the character of the developing organism can be distinguished from the effects of the cytoplasm.
E. the effects of chromosomes on the character of the developing organism cannot be distinguished from the effects of the environment.

Below is a pedigree of myopia (nearsightedness) which, presumably, is transmitted by a single pair of genes. Individuals affected by myopia are shown by shading. After each exercise number on the answer sheet, blacken the *one* lettered space which indicates the best or correct answer.



201. (2.20) From a closer study of the pedigree, myopia is inherited as

A. a dominant characteristic.
B. an ordinary recessive. **C.** a sex-linked recessive.
D. an incompletely dominant characteristic.
E. none of the four.

202. (2.20) Individual 1 in the pedigree

A. is heterozygous for this condition.
B. is homozygous for myopia.
C. is homozygous for the normal condition.
D. transmits the gene for myopia only to her sons.
E. transmits the gene for myopia only to her daughters.

203. (2.20) From the evidence submitted in the pedigree, individual 2

A. is homozygous for myopia.
B. is homozygous for the normal condition.
C. is heterozygous for the normal condition.
D. is none of the above.

204. (2.20) In individual 3

A. both genes are for the normal condition.
B. one gene is definitely for the normal condition and the other a gene for myopia.
C. both genes are for myopia.
D. sufficient evidence is not present in the pedigree to point to a definite gene combination.

205. (2.20) Individual 4 is

A. definitely homozygous for the normal condition.
B. homozygous for the myopic condition.
C. definitely heterozygous for the normal condition.
D. not proven by the evidence to be one of the above.

206. (2.20) To individual 5

A. each parent contributes a dominant gene.
B. one parent contributes a dominant gene and the other a recessive gene.
C. each parent contributes a recessive gene.
D. the kind of a gene contributed by each parent cannot be determined from the pedigree.

207. (2.20) In individual 6

A. the heterozygous condition for normal prevails.
B. two like dominant genes are present.
C. two like recessive genes are found.
D. gene combination cannot be ascertained for lack of sufficient evidence.

208. (2.20) Individual 7

A. receives a dominant gene from the father and a recessive gene from the mother.
B. receives a dominant gene from the mother and a recessive gene from the father.
C. receives a dominant gene from both parents.
D. receives a recessive gene from both parents.
E. has a father who is homozygous for the normal conditions.

209. (2.20) In order to have a myopic child like individual 8 in the pedigree

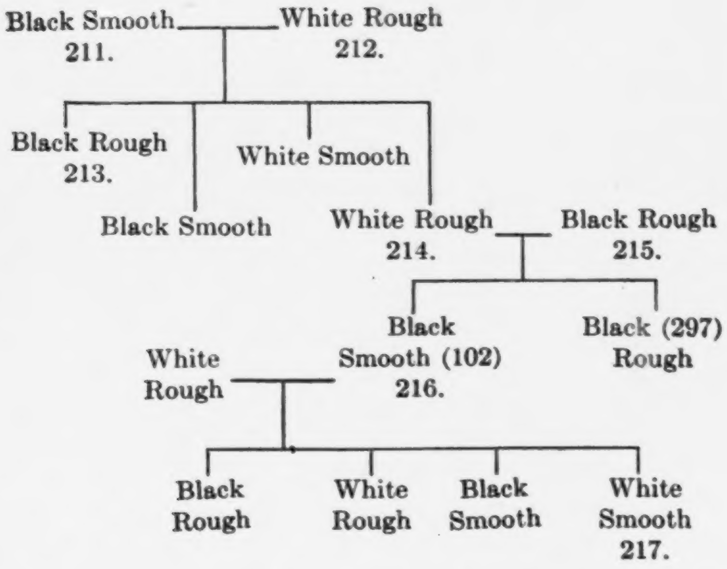
A. both parents must carry only dominant genes.
B. both parents must carry recessive genes.
C. one parent may contribute a dominant gene and the other a recessive gene.
D. the father transmits the recessive gene.
E. none of the situations hold true.

210. (2.20) When both parents are affected by myopia

A. all their children will have myopic vision.
B. only their daughters will be affected.
C. only their sons will be affected.
D. one half of their children will be normal and one half will have myopia.
E. no definite ratio of normal to myopic individuals will result.

In the following diagram of guinea pig matings, consider that enough matings between parents of identical heredity have been made to give the number of offspring indicated in the parentheses. (B) black is dominant over (b) white, and rough (R) is dominant over smooth (r). After the number on the answer sheet corresponding to that of each numbered phenotype, blacken space. (All are 2.20)

A if genotype is BBRr.
B if genotype is BbRr.
C if genotype is Bbrr.
D if genotype is bbRr.
E if genotype is bbrr.



The inheritance of singing voice has been found to have the following genetic basis:

Genotype	*Phenotype*
AA	Bass in the male, soprano in the female.
Aa	Baritone in the male, mezzo-soprano in the female.
aa	Tenor in the male, alto in the female.

Items 218 - 221.

After each exercise number on the answer sheet, blacken the *one* lettered space which designates the correct answer.

218. (2.20) If the mother is a soprano and the father a bass, the singing voices of their sons are most likely to be

A. baritone only. **B.** bass only.
C. either baritone or bass.
D. either baritone or tenor.
E. either bass or tenor.

219. (2.20) If the mother is an alto and the father a tenor, the singing voices of their daughters are most likely to be

A. alto only. **B.** soprano only.
C. mezzo-soprano only. **D.** either alto or soprano.
E. either soprano or mezzo-soprano.

220. (2.20) If the mother is an alto and the father a bass, the children are most likely to be

A. bass sons, soprano daughters.
B. bass sons, mezzo-soprano daughters.
C. baritone sons, mezzo-soprano daughters.
D. tenor sons, mezzo-soprano daughters.

221. (2.20) If the mother is a mezzo-soprano and the father a baritone, the children are most likely to be

A. bass sons, soprano daughters.
B. bass sons, alto daughters.
C. baritone sons, mezzo-soprano daughters.
D. baritone sons, alto daughters.
E. tenor sons, soprano daughters.

Items 222 - 237. After each item number on the answer sheet, blacken space

A if the statement refers only to the inheritance of traits due to a single dominant gene that always expresses itself.
B if the statement refers only to sex-linked recessive inheritance.
C if the statement refers only to the inheritance of traits due to ordinary (autosomal) recessives.
D if the statement refers only to inheritance where dominance fails.
E if the statement refers only to inheritance due to the interaction of two or more genes.

222. (2.20) The heterozygous offspring can always be distinguished by their appearance.

223. (2.20) A character that always develops when its gene is present.

224. (2.20) Inheritance due to a single pair of genes may appear in any offspring even though neither parent shows the trait.

Item 225 deleted.

226. (2.20) In certain inheritance due to a single pair of genes, when two homozygous individuals that differ in appearance are crossed, the offspring resemble only one parent.

227. (2.20) In chickens a mating of walnut comb with walnut results in $\frac{9}{16}$ walnut; $\frac{3}{16}$ rose; $\frac{3}{16}$ pea; $\frac{1}{16}$ single.

228. (2.20) Even though the father has no genes to contribute to such inheritance, sons may exhibit a trait that does not appear in the mother but is transmitted by her.

229. (2.20) If the father exhibits the character and the mother does not possess a single gene for the trait, all of the sons will be without a single gene for the trait and all the daughters will be carriers.

230. (2.20) Such inheritance is exhibited much more frequently in males than in females.

Item 231 deleted.

232. (2.20) A father is unable to transmit such inheritance to his sons.

233. (2.20) Either parent may be a carrier of such inheritance.

234. (2.20) The heterozygous offspring always differ in appearance from either purebred parent.

235. (2.20) Such inheritance always shows in sons, but may be concealed in daughters.

236. (2.20) Only one member of a pair of genes for such inheritance is ever present in fathers and sons.

237. (2.20) Only the female can be heterozygous for such inheritance.

238. (2.20) An albino corn plant lacks chlorophyll and therefore cannot manufacture its own food. Continuance of this genetic character in seed plants occurs because

A. the albino stocks can breed true.
B. the albino seed plants can live without chlorophyll.
C. the albino seed plants can be produced through self-pollination of pure normal plants.
D. the character is carried by normal plants.
E. it crops up continually through mutation.

239. (2.20) How should one correctly interpret the statement "John has one fourth Indian blood in his veins"?

A. some of his genes were from an Indian ancestor.
B. one fourth of his blood was contributed by an Indian ancestor.

C. one of his grandparents was a full-blooded Indian.
D. Indian blood cells contribute to his embryonic development.
E. his Indian blood has become diluted.

240. In Drosophila, if two pairs of characters are linked
(2.20) and autosomal, the sort of cross from which the cross-over value between the characters is most readily obtained is between a
______________ male and a ______________ female.

241. In Drosophila, if two pairs of characters are both sex-
(2.20) linked, the sort of cross which definitely displays their linkage with the smallest number of offspring is between a
______________ male and a ______________ female.

242. In a cross involving two pairs of characters between
(2.20) two pure strains, the first generation in which it is apparent that the two pairs of characters are linked or independent is the
____

243. In Drosophila, if two pairs of characters are both sex-
(2.20) linked, in any set of offspring from which cross-over values can be calculated, which sex(es) is (are) most likely to be usable?
____

244. It is very difficult to determine the sex of newly hatched
(3.00) chicks. However, let us assume that it is quite easy to tell whether or not a chick has a certain sex-linked recessive character. In chickens the male has two X-chromosomes and the female has an X and a Y which is exactly the reverse of the situation in human beings. Which of the following crosses would enable a poultry breeder to determine the sex of his newly hatched chicks by taking advantage of the above information: (X = sex-linked trait)

A. Rooster ⊕⊕; Hen Xy
B. –; Hen ⊕Y
C. –; Hen ⊕Y
D. –
E. Rooster ⊕⊕; –

245. Geneticists who have worked on schizophrenia have
(3.00) postulated that individuals possessing the genes for this trait will not exhibit the symptoms unless they are faced with certain problems and frustrations. This view, held by geneticists,

A. excludes the role of the environment.
B. recognizes the dominant role of heredity in determining mental traits.
C. recognizes the dual role of heredity and environment in determining the traits of an individual.
D. recognizes the dominant role of the environment in this case.
E. minimizes the effect of the environment.

Questions 246 - 250. In certain locusts sex is determined according to the XX-XO formula. There are six pairs of chromosomes exclusive of the X chromosomes in both male and female. The following classes of cells are present in relation to chromosome numbers:

A. 14 chromosomes. **B.** 13 chromosomes.
C. 7 chromosomes. **D.** 6 chromosomes.
E. 6 or 7 chromosomes.

To which of the above groups would each of the following cells belong?

246. Fertilized egg which will develop into a female.
(3.00)

247. Fertilized egg which will develop into a male.
(3.00)

248. Mature ovum.
(3.00)

249. Mature sperm.
(3.00)

250. Second polar body.
(3.00)

251. A family is most likely to have a child afflicted with
(3.00) Erythroblastosis fetalis if

A. the father is Rh-negative and the mother is Rh-positive.
B. both parents are Rh-positive.
C. both parents are Rh-negative.
D. the father is Rh-positive and the mother is Rh-negative.
E. one or both parents have Erythroblastosis.

Before attempting to answer items 252 - 276 read the following paragraphs and refer to the genealogies on page 221.

Two white children were born to two different mothers at the same time in a hurricane shelter in which hundreds of people had sought refuge. In the attendant darkness, panic, and confusion, the infants were not properly identified by those who assisted; consequently neither mother was quite certain which child was hers.

A year has elapsed and steps are now being taken to establish on the basis of the more apparent hereditary traits the true parentage of each child. Genealogies of each family have been compiled by a committee consisting of a geneticist, a physician, and a social worker trained in psychiatry. You are to assume the role of the geneticist on this committee and render judgment based upon the principles of heredity which have been presented in Biological Science.

In the genealogies presented on the opposite page a square represents a male individual while a circle represents a female. The two parents (and the brothers and sisters of the parents) as well as the four grandparents of each child are represented in each genealogy. It will be noted that the same people appear repeatedly as each genealogy traces the family history of several different traits. The parents of the two children whose parentage is to be established are designated as Couple I and Couple II respectively.

The children whose parentage is to be established (one child is a boy and the other a girl) are desribed as follows:

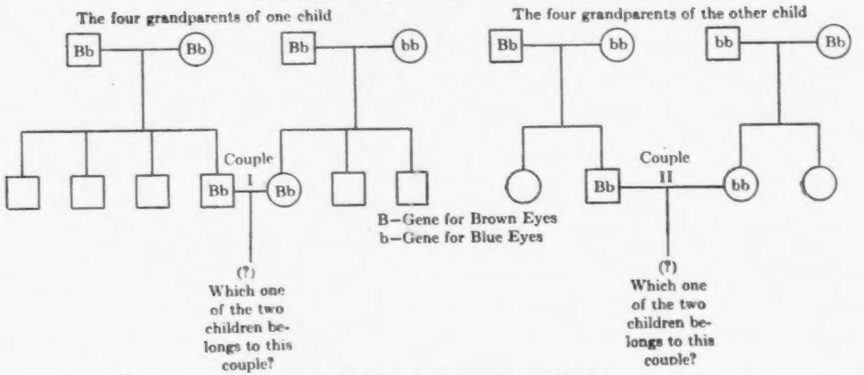
The Boy	*The Girl*
1. is brown-eyed.	**1.** is blue-eyed.
2. has type B blood.	**2.** has type O blood.
3. has normal mentality.	**3.** is feebleminded.
4. is hemophilic (a free-bleeder).	**4.** is not hemophilic.
5. has red curly hair.	**5.** has straight brown hair.

For items 252 - 258 select the one best answer in each case

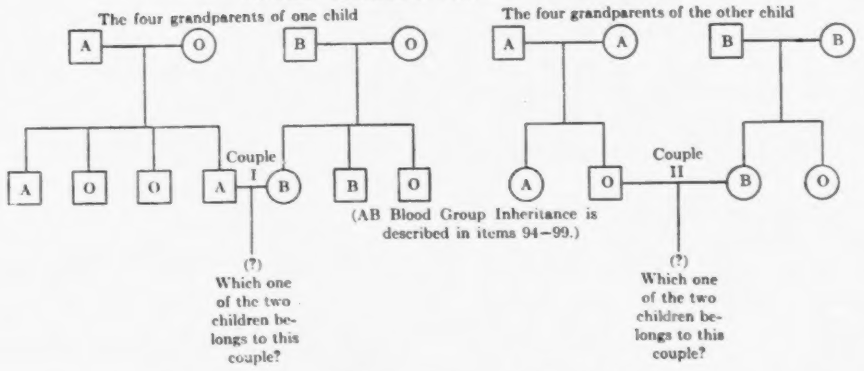
252. On the basis of eye-color inheritance
(3.00)

A. the girl could belong to Couple II only.
B. the boy could belong to either couple.
C. the boy could belong to Couple I only.

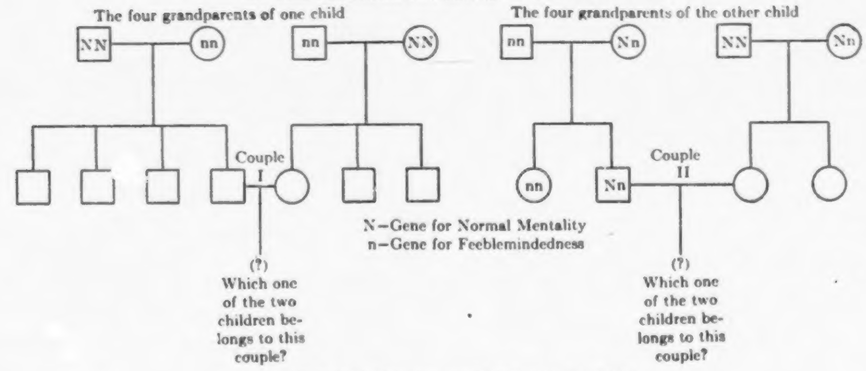
EYE-COLOR INHERITANCE IN THE FAMILIES INVOLVED IN ITEMS 252–257


The four grandparents of one child
The four grandparents of the other child
Bb
Bb
Bb
bb
Bb
bb
bb
Bb
Couple I
Bb
Bb
Couple II
Bb
bb
B—Gene for Brown Eyes
b—Gene for Blue Eyes
(?) Which one of the two children belongs to this couple?
(?) Which one of the two children belongs to this couple?

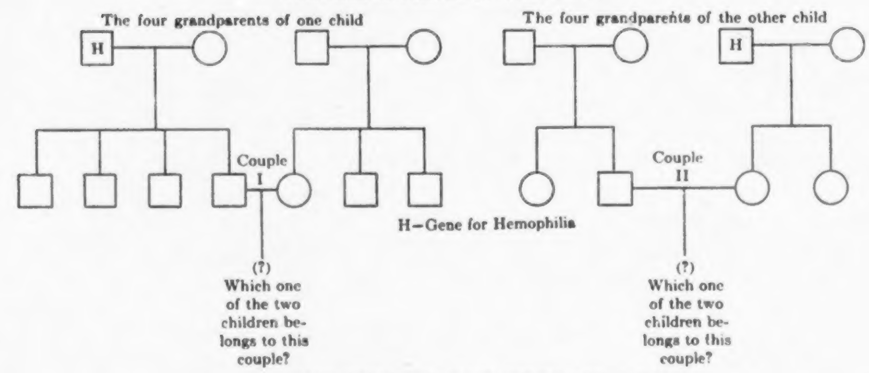
AB BLOOD GROUP INHERITANCE IN THE FAMILIES INVOLVED IN ITEMS 252–257


The four grandparents of one child
The four grandparents of the other child
A
O
B
O
A
A
B
B
A
O
O
A
Couple I
B
B
O
A
O
Couple II
B
O
(AB Blood Group Inheritance is described in items 94–99.)
(?) Which one of the two children belongs to this couple?
(?) Which one of the two children belongs to this couple?

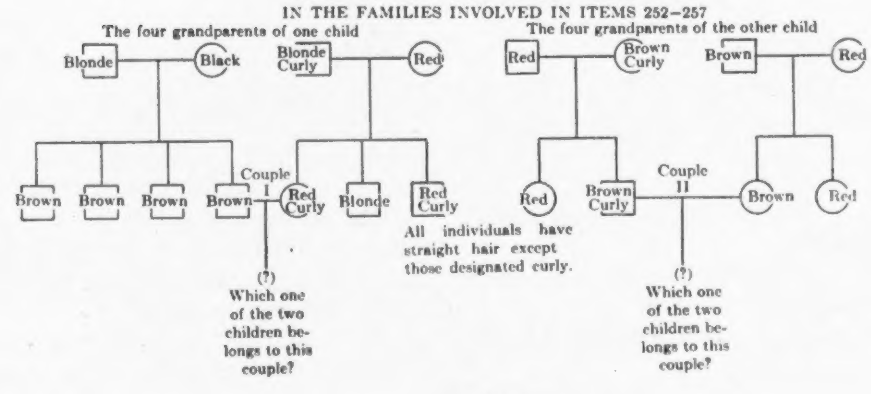
INHERITANCE OF FEEBLEMINDEDNESS IN THE FAMILIES INVOLVED IN ITEMS 252–257


The four grandparents of one child
The four grandparents of the other child
NN
nn
nn
NN
nn
Nn
NN
Nn
Couple I
nn
Nn
Couple II
N—Gene for Normal Mentality
n—Gene for Feeblemindedness
(?) Which one of the two children belongs to this couple?
(?) Which one of the two children belongs to this couple?

INHERITANCE OF HEMOPHILIA IN THE FAMILIES INVOLVED IN ITEMS 252–257


The four grandparents of one child
The four grandparents of the other child
H
H
Couple I
Couple II
H—Gene for Hemophilia
(?) Which one of the two children belongs to this couple?
(?) Which one of the two children belongs to this couple?

HAIR FORM AND HAIR COLOR INHERITANCE IN THE FAMILIES INVOLVED IN ITEMS 252–257


The four grandparents of one child
The four grandparents of the other child
Blonde
Black
Blonde Curly
Red
Red
Brown Curly
Brown
Red
Brown
Brown
Brown
Brown
Couple I
Red Curly
Blonde
Red Curly
Red
Brown Curly
Couple II
Brown
Red
All individuals have straight hair except those designated curly.
(?) Which one of the two children belongs to this couple?
(?) Which one of the two children belongs to this couple?

- **D.** it is possible to decide the parentage of the girl, but the boy's parentage can be established only indirectly.
- **E.** of the various genealogies, this one gives the most conclusive evidence of the parentage of each child.

253. (3.00) On the basis of AB blood group inheritance

- **A.** the girl could not possibly belong to Couple I.
- **B.** the boy could not possibly belong to Couple I.
- **C.** the boy or the girl could belong to either couple.
- **D.** the parents of one child can be established directly, and the parents of the other child by elimination.
- **E.** neither child fits either inheritance pattern.

254. (3.00) On the basis of feeblemindedness inheritance

- **A.** the girl would most likely belong to Couple I.
- **B.** the boy would most likely belong to Couple I.
- **C.** approximately half of Couple II's children would likely be feebleminded.
- **D.** most of Couple I's children are likely to be feebleminded.
- **E.** neither Couple I nor Couple II could have any grandchildren with normal mentality.

255. (3.00) On the basis of hemophilia inheritance.

- **A.** the boy would belong to Couple I.
- **B.** the boy would belong to Couple II.
- **C.** the girl would belong to Couple II only.
- **D.** the girl could belong to Couple II only.
- **E.** it is impossible to establish the probable parentage of either child.

256. (3.00) On the basis of hair-form and hair-color inheritance

- **A.** the boy would be more likely to belong to Couple I than to Couple II.
- **B.** the girl would be more likely to belong to Couple II.
- **C.** the boy could not possibly belong to Couple II.
- **D.** the parents of each of the two children could be definitely determined.
- **E.** it is not possible to establish the parentage of either child.

257. (3.00) These two children can be identified with their true parents on the basis of

- **A.** eye color alone. **B.** hair characteristics alone.
- **C.** a blood characteristic alone.
- **D.** mentality alone.
- **E.** none of the above-named traits alone.

258. (3.00) One trait which gives the clue to the identity of the children is

- **A.** sex-linked.
- **B.** inherited by receiving two of the three possible genes for the trait.
- **C.** of multiple-gene causation.
- **D.** a recessive trait. **E.** their sex.

For items 259 - 276 some of which also refer to the foregoing genealogies, mark space

- A if the statement is true and/or the genealogy data supports the statement.
- B if the statement is false and/or the genealogy data contradicts the statement.
- C if the statement is not decisively settled one way or the other.

NOTE: Before working out the answers to items 259 - 276 the boy and girl involved in items 252 - 258 are to be placed in their proper families on the basis of preceding data. They are to be considered the third generation of their respective families.

259. (3.00) Matching blood type gives positive, impartial evidence that a particular child in question belongs to a certain couple and cannot belong to anyone else.

260. (3.00) Active hemophilia does not appear in the children of an afflicted father.

261. (3.00) The gene for feeblemindedness from a feebleminded individual could pass on in heredity for several generations without producing any feebleminded descendant.

262. (3.00) The inheritance of two dominant genes for hair color produces dark brown or black hair.

263. (3.00) Regardless of race, curly hair is dominant to straight hair.

264. (3.00) If one parent has type A blood and the other parent has type B blood there must be either an A or a B factor, or both, present in their child's heredity.

265. (3.00) Some normal individuals carry genes for feeblemindedness.

266. (3.00) The gene(s) for type O blood is (are) recessive.

267. (3.00) Hemophilia is due to a recessive gene.

268. (3.00) The easiest trait to breed out of the population is one due to a single recessive gene.

269. (3.00) Race improvement in mankind could easily be achieved by applying the same principles that are used in developing a pure breed of animal.

270. (3.00) If a male individual acquires the gene for a sex-linked trait, that trait is certain to be manifest since there is lacking any normal counteracting gene.

Continue using the same key as for items 259 - 269 If the boy and girl involved in items 252 - 256 were to marry when they have grown to maturity,

271. (3.00) the chances of any one of their children being feebleminded are at least 3 to 1 or 75%.

272. (3.00) the likelihood of their having any homozygous brown-eyed children would be 0.

273. (3.00) their likelihood of having any children with type A blood would be 0.

274. (3.00) the likelihood that any child they may have will be a free-bleeder is 1 : 1 or 50%.

275. (3.00) the likelihood that any child they may have will be wavy-haired is just about 100%.

Items 376 - 381 involve the following incidents:

During 1945 a gardener planted one row of red phlox seed adjacent to a row in which white phlox seeds were planted. Only red flowers appeared in the first row and only white flowers in the second. Seeds obtained from these plants were artificially pollinated with red flower pollen. All plants grown from this seed produced red flowers. Assuming that the plantings represented adequate samples, evaluate the statements below according to the following key.

KEY

- **A.** The evidence suggests that the statement is probably true.
- **B.** The evidence suggests that the statement is probably false.
- **C.** The evidence is insufficient to indicate marked degree of truth or falsity.

276. (3.00) In phlox, red color shows reduced penetrance when genes for red and white appear in the same individual.

277. (3.00) There is a recessive gene for pink color in phlox plants.

278. (3.00) One generation of phlox plants depletes the soil of certain elements essential for the normal development of pigments.

279. (3.00) There were nearly as many pink flowers in the 1946 crop as red and white flowers combined.

280. (3.00) Phlox plants can be either self- or cross-pollinating.

281. (3.00) The original seed planted in 1945 was homozygous.

282. (4.20) An example given in the course readings which is most readily interpreted as a "specific response of nuclear genes to local differences" would be

- **A.** the formation of "Exercierknochen" on the collar bones of soldiers.
- **B.** the formation of half-maternal and half-hybrid plutei in sea-urchins with delayed fertilization.
- **C.** the formation of an entire embryo from 1/16 of the zygote nucleus in half the zygote cytoplasm after partial constriction of the amphibian egg.
- **D.** the action of the genes differentiating anophthalmic from normal mice on the optic vesicle during its period of growth.
- **E.** the appearance of a specific adult lens substance in the lens primordium before it differentiates the fibers characteristic of the adult lens.

283. (4.10) An assumption made in accounting for inheritance in peas which Mendel does not find has to be discarded or modified in accounting for special cases of inheritance in other plants is that

- **A.** the results of reciprocal crosses are equivalent.
- **B.** the hybrid resembles one parent only in each of its characters, though not necessarily the same parent in all characters.
- **C.** in the offspring of hybrids, as many combinations of the parental characters appear as are conceivable.
- **D.** each of the characters of a plant is governed by a single independently inherited pair of factors.
- **E.** the only means of producing a constant-breeding individual is by the fertilization of an egg with like pollen.

284. (4.10) The number of different forms under which the offspring of hybrids appear eventually gives Mendel a clue as to

- **A.** the reason for dominance.
- **B.** how many kinds of pollen and eggs are produced by the hybrids.
- **C.** the frequency with which the various kinds of pollen and eggs are produced by the hybrids.
- **D.** the effects of repeated inbreeding on the proportion of recessive offspring in a generation.
- **E.** none of the foregoing.

285. (4.00) Mendel gives two notations for the F_2 generation from a monohybrid cross: (i) A + 2Aa + a; and (ii) $\frac{A}{A} + \frac{A}{a} + \frac{a}{A} + \frac{a}{a}$. The distinction between these two in Mendel's usage is that

- **A.** (i) is the shorter formulation and is used more frequently, but has the same significance as (ii).
- **B.** (i) can be derived from breeding data without obtaining an F_3 generation, whereas (ii) is established only on the basis of an F_3.
- **C.** (ii) can be derived from breeding data without obtaining an F_3 generation, whereas (i) is established only on the basis of an F_3.
- **D.** (i) is a summary of breeding results, while (ii) is a prediction of proportions of types of F_3 offspring on the basis of the types of gametes the F_2 produces.
- **E.** (i) is a summary of breeding results, while (ii) signifies the (fertilized) combinations of gametes produced by the F_1.

286. (2.20) Mendel's chief aim in his experiments in plant-hybridization is to

- **A.** discover the laws generally applicable to the formation of hybrids and their offspring.
- **B.** demonstrate the universal application of the phenomena of dominance.
- **C.** invalidate Darwin's theory of evolution by explaining Darwin's "new variations" in terms of segregation of heritable factors already present.
- **D.** uphold the doctrine of the strict separation of the inheritable (germinal) from the non-inheritable (somatic) protoplasm.
- **E.** discover how seven characters are inherited in peas.

287. (4.20) In view of his criticism of the breeding experiments performed by his predecessors, Mendel apparently considered that

- **A.** not enough work had been done on a wide enough variety of organisms for the general pattern of inheritance to emerge.
- **B.** his predecessors had not found a truly typical organism on which to experiment.
- **C.** his terms "hybrid" and "species" need to be defined more clearly and used more consistently if one person's results are to be compared with another's.
- **D.** they had too few implications for the problem of organic evolution, which at that time was one of the major issues in biology.
- **E.** a mathematical analysis of data is essential to the induction of general laws of inheritance.

288. (4.20) The number of different forms under which the offspring of hybrids appear eventually gives Mendel a clue as to

- **A.** the reason for dominance.
- **B.** how many kinds of pollen and eggs are produced by the hybrids.
- **C.** the frequency with which the various kinds of pollen and eggs are produced by the hybrids.
- **D.** the effects of repeated inbreeding on the proportion of recessive offspring in a generation.
- **E.** none of the foregoing.

289. (4.20) Mendel's requirement that the offspring of hybrids should be arranged with certainty according to their separate generations was found to be particularly necessary in view of the fact that

A. hybrids produced constant-breeding as well as hybrid offspring
B. some of the parental traits did not appear in the hybrids.
C. the gametes produced by the hybrids were always of the same sorts.
D. the number of kinds of gametes produced by the hybrids depended on the number of pairs of alternative characters combined in the hybrids.
E. hybrids between varieties of the same species are more fertile than hybrids between distinct species.

290. (2.20) The test Mendel applied to insure that his experimental plants possessed constant differentiating characters was to

A. cross them and determine whether a clear 3 : 1 ratio appeared in the F_2.
B. cross them and determine whether the F_1 hybrid resembled one parent to the exclusion of the other or was intermediate between the two parents.
C. allow them to propagate by self-fertilization for two successive years.
D. note whether the characters were of a measurable or of an all-or-none kind.
E. examine the relation of the petals to the reproductive organs of the flower.

291. (4.20) If the hybrids and their offspring suffered a marked disturbance in their fertility, the most serious consequence would be that

A. the proportions of types of offspring would bear an unknown relation to the proportions of types of gametes.
B. which character is dominant and which is recessive could not be discovered with certainty.
C. a test of Mendel's prediction about the effect of repeated self-fertilization on the proportions of hybrid and constant offspring in the tenth generation would be nearly impossible to perform.
D. there would be no means of verifying Mendel's theory that there are as many sorts of both egg and pollen cells produced as there are possible constant combination forms.

292. (4.20) In his explanation of his results Mendel postulates that all of the gametes of the constant dominant parents, **A**, are alike because

A. gametes must be identical to the individual who produces them.
B. any combination of two gametes will then be the same, i.e., AA.
C. all gametes receive ½ of their mother cell's nucleus and in this case both halves are the same.
D. all of the gametes appeared the same so Mendel gave them one name.
E. when **A** is crossed with **a** the result is **Aa**.

293. (4.20) Mendel was then able to postulate that the monohybrid (**Aa**) form had *two* kinds for gametes, **A** and **a**, because

A. the monohybrid when self-fertilized produces two genotypes, **A** and **a**.
B. the monohybrid when self-fertilized produces two kinds of constant forms, **A** and **a**.
C. the monohybrid when self-fertilized produces two phenotypes, dominant and recessive.
D. the hybrid is produced by a union of **A** and **a** and so it is natural that when it produces gametes they should also be **A** and **a**.
E. each gamete receives ½ of the mother cell's nucleus and ½ of **Aa** is either **A** or **a**.

294. (2.10) Weismann replaces the concept of the inheritance of acquired characters by the concept of

A. quantitatively equal nuclear divisions.
B. qualitatively unequal nuclear division.
C. inheritance of tendencies to acquire characters.
D. quantitative analysis of breeding results.
E. development in accordance with external, rather than internal, determining factors.

295. (4.20) The evidence on which Weismann bases his conclusion that the nucleus of the germ cell is the sole bearer of heredity is that

A. in some instances of fertilization only the nucleus of the male germ cell enters the egg cell.
B. the first cleavage plane can be oriented in various directions through the zygote cytoplasm without affecting the embryo.
C. in cell division the cytoplasm always divides equationally.
D. in cell division the chromosomes always divide equationally.
E. the direction of the first cleavage plane in the embryo is determined by the direction of the first nuclear spindle.

296. (4.20) In view of his theory of nuclear differentiation, the normal process whose disturbance is, for Weismann, most likely to result in abnormal embryonic development is

A. the rotation of the frog egg so that the animal pole is up.
B. the development of inhomogeneities within the egg cytoplasm.
C. genetic segregation in gamete formation.
D. cell division.
E. rate of assimilation of nutrients.

297. (4.20) The chromosomal behavior in which *one* of the following instances lends most support to Weismann's interpretation of development? (All are found in nature.)

A. In *Ascaris megalocephala* (a parasitic round-worm) fertilization is accompanied by the fusion of egg and sperm nuclei, each containing a single long chromosome, so that the zygote nucleus contains a pair of long chromosomes.
B. In *Ascaris megalocephala,* in each of the first three cleavages, the ends of the long chromosomes disintegrate in one of the daughter cells and the remainder breaks up into numerous chromosomes. Thus, only one of the eight cells has the pair of intact chromosomes, that cell giving rise only to germ cells. The fate of each cell is already determined by this time.
C. In germ-cell formation in *Ascaris megalocephala,* the pair of chromosomes synapse and split. Two successive cell divisions result in four gametes for each primary gametocyte, each containing one long chromosome.
D. In the fertilized frog egg, the paternal and maternal nuclei approach each other but do not fuse before the first nuclear division. The spindle is oriented so

250

that the chromosomes of both are in the metaphase plate.

E. The first cleavage plane in amphibia is sometimes medial and sometimes frontal, with reference to the resulting embryo, the axis of the embryo depending on the position of the gray crescent material near the surface of the cytoplasm.

298. (4.20) The evidence presented by Sutton and Morgan that the chromosomes are indeed the bearers of heredity, together with the widespread occurrence of equational mitosis,

A. weakens Weismann's position on the separation of the germ line from the soma.
B. strengthens Weismann's position on the separation of the germ line from the soma.
C. weakens Weismann's position on the role of the nucleus in embryonic development.
D. strengthens Weismann's position on the role of the nucleus in embryonic development.
E. weakens Weismann's position on the role of the nucleus in heredity.

299. (4.20) From the phenomena of crossing-over it is possible to infer that

A. a single allelomorph can change from recessive to dominant or vice versa.
B. allelomorphs can occupy positions on non-homologous chromosomes.
C. the different pairs of chromosomes segregate independently into the gametes at meiosis.
D. the genes occupy fixed positions along the length of the chromosomes.
E. chromosomes in synapsis always exchange sections.

300. (4.10) The phenomenon of "linkage" was

A. anticipated by Mendel.
B. anticipated by Sutton.
C. contradictory to Mendel's theory of purity of gametes.
D. contradictory to Sutton's theory that all maternal chromosomes are regularly separated in meiosis from all paternal chromosomes.
E. none of the foregoing.

301. (5.00) Briefly state why an understanding of meiosis is essential to an understanding of genetics.

302. (3.00) In stock farming, selecting breeding stock by choosing those animals which look the best

A. will insure desirable offspring.
B. is based upon the assumption that heredity is a more potent factor than environment.
C. fails to take into account the inheritance of recessive traits.
D. is known as breeding by the pedigree system.
E. is known as the progeny test.

303. (3.00) The greatest potential reservoir for new characteristics in a race of organisms will result from

A. inbreeding of closely related individuals.
B. crossing distantly related individuals of widely differing characteristics.
C. allowing the organisms to freely interbreed.
D. developing certain traits in the organisms by exercise and diet, then transmitting these acquired traits to the progeny.
E. naturally occurring and artificially induced mutations.

304. (3.00) Vestigial wings and eyelessness are two recessive characteristics in fruit flies. If a vestigial-winged eyeless fly were to be bred to a pure normal-winged fly with normal eyes, the safest prediction, disregarding environmental factors, regarding the second inbred generation from this cross would be that

A. one sixteenth of all the individuals from all the broods will be vestigial-winged and eyeless individuals.
B. every sixteenth fly would be eyeless and have vestigial wings.
C. one sixteenth of all the individuals hatched in the first brood would be eyeless and vestigial-winged individuals.
D. any of these three predictions, each is equally sound.
E. none of these three predictions, none is sound.

Items 305 - 314 refer to the following excerpts from the records kept by a plant breeder during an experiment.

In 1944 red phlox seed was planted in a row adjacent to a row in which white phlox seed was planted. Only red flowers appeared in the first row and only white phlox in the second row. Seeds obtained from these plants were planted in 1945 and produced red, white, and pink flowers. In 1946 seeds collected from the 1945 crop of pink flowers were planted and produced red, white, and pink flowers.

305. (3.00) The best statement of the problem confronting this breeder is:

A. Is red color dominant over white?
B. Is white dominant over red?
C. Is there an environmental factor that diminishes color intensity in phlox?
D. Was the red and white phlox seed from homozygous parents?
E. Why do red and white phlox appear from seed produced from pink phlox?

Items 306- 314.

A student attempted to solve this breeder's problem for him. Evaluate the statement he made according to the key.

KEY

A. Directly pertinent to the solution of the problem and in accord with accepted knowledge of genetics.
B. Directly pertinent to the solution of the problem but not in accord with accepted knowledge of genetics.
C. Unrelated to the solution of the problem but accurate.
D. Unrelated to the solution of the problem and inaccurate.

306. (3.00) The pink flowers represent a blending of the red and white color factors.

307. (3.00) It is possible for some flowers to be either self- or cross-pollinated.

308. (3.00) The presence of the genes of some characteristics will cause genes of non-corresponding characteristics to be totally repressed.

309. (3.00) Phlox plants deplete the soil so thoroughly that a crop cannot grow normally in that soil thereafter.

310. (3.00) Some genes are neither dominant nor recessive to each other.

311. (3.00) If seeds from pink phlox were to be planted the crop would yield two pink flowers for each red or white flower.

312. (3.00) The only sure way to raise all pink phlox is to save the seeds from a red plant that was pollinated by a pink flower.

313. (3.00) If the white flowered phlox grown from the pink phlox seed are all self-pollinated their seeds will produce all pink flowers.

314. (3.00) It is possible for chemical substances to be applied to plants to change the color of their flowers.

315. (3.00) The scientific method would be applicable in all of the following situations *except*

- **A.** determining the curative powers of a patent cancer cure.
- **B.** determining whether penicillin kills the bacteria that cause a specific type of pneumonia.
- **C.** examining a merchandising program to determine whether or not sales could be increased.
- **D.** determining the solution to a crime.
- **E.** None of the above—the scientific method could be applied in all of the four cases.

Items 316 - 323 refer to the following account.

There is a breeder of small animals who specializes in raising unique types of individuals. In one project he crossed a male homozygous black smooth hair guinea pig with a female homozygous white rough hair guinea pig. All of the offspring of this cross turned out to have black rough hair. One of his customers who bought a pair of these black rough hair guinea pigs was surprised to find that none of the offspring they produced had black rough hair. The customer confronted the dealer and demanded an explanation.

316. (3.00) The best statement of the problem faced by the dealer would be:

- **A.** How can I explain genetical penetrance to the customer?
- **B.** How can I explain incomplete dominance to the customer?
- **C.** How can I apologize for allowing the customer's female guinea pig to mate before selling her?
- **D.** How can I explain that the thickness of an animal's fur depends upon the weather?
- **E.** How can I explain mathematical odds and their relation to heredity?

For items 317 - 322 evaluate the statements made by the dealer in explaining to his customer according to the key.

KEY

- **A.** Directly pertinent to the solution of the problem and in accord with accepted knowledge of genetics.
- **B.** Directly pertinent to the solution of the problem but not in accord with accepted knowledge of genetics.
- **C.** Unrelated to the solution of the problem but accurate.
- **D.** Unrelated to the solution of the problem and inaccurate.

317. (3.00) In guinea pigs, black hair color is dominant over white.

318. (3.00) The period of gestation for guinea pigs is less than thirty days.

319. (3.00) It is impossible to accurately forecast the inheritance of any characteristics when dealing with a group of homozygous guinea pigs even though their pedigrees are known.

320. (3.00) The appearance of no black rough hair guinea pigs in the litter of this pair in question was purely circumstantial. Their next litter may all be black rough hair individuals.

321. (3.00) If a black rough hair guinea pig mates with a white smooth hair individual the characteristics of all offspring produced by subsequent matings may be affected.

322. (3.00) There was one white smooth hair individual in the first litter of this pair. This proves that the female sold to the customer had mated with a stray guinea pig before being sold.

323. (3.00) The problem confronting this breeder of guinea pigs best illustrates the necessity of conducting scientific experiments with

- **A.** an adequate control.
- **B.** all environmental conditions accounted for.
- **C.** proper caution to prevent unexpected factors.
- **D.** an adequate sample.
- **E.** a well-clarified hypothesis at the beginning of the experiment.

Items 324 - 329 refer to an account of an experiment.

A male homozygous non-grizzly black mouse was obtained from a breeding laboratory and crossed with a female grizzly brown mouse obtained from a pet store where her pedigree was unavailable. In their first litter there were seven young, although one died. Four of the survivors were black grizzly while two were non-grizzly black.

Evaluate the statements according to the following key.

KEY

- **A.** The evidence is sufficient to make the statement true.
- **B.** The evidence is sufficient to make the statement false.
- **C.** The evidence suggests that the statement is probably true.
- **D.** The evidence suggests that the statement is probably false.
- **E.** The evidence is insufficient to make a decision concerning the statement.

324. (3.00) Black coat color is dominant over brown.

325. (3.00) Grizzly is dominant over non-grizzly.

326. (3.00) Spotting in mouse coat color is a recessive characteristic.

327. (3.00) If grizzly is a dominant character, the female mouse is homozygous for grizzly.

328. (3.00) The mouse which died was a black mouse.

329. (3.00) If these parents are bred together several times, about half of the offspring would be non-grizzly.

Items 330 - 342.

There are four phenotypes in the A-B blood group in humans. The inheritance of these conditions is governed by a multiple allele mechanism consisting of three genes I^a, I^b, and i. Between

I^a and I^b there is no dominance, both I^a and I^b are dominant over i. The genotypes and the phenotypes due to them are as follows:

Genotype	*Phenotype*
I^aI^b	Blood type AB.
I^aI^a or I^ai	Blood type A.
I^bI^b or I^bi	Blood type B.
ii	Blood type O.

After the item number on the answer sheet, blacken space

- **A** if the mother referred to in the item is blood type A.
- **B** if the mother referred to in the item is blood type B.
- **C** if the mother referred to in the item is blood type AB.
- **D** if the mother referred to in the item is blood type O.
- **E** if the mother referred to in the item can be of more than one of the above blood types.

330. (3.00) Neither of the mother's parents could have been type O.

331. (3.00) The father was type A and there were children with type A, type B and type AB blood.

332. (3.00) The father was type O and all of the children were either types A or B.

333. (3.00) The father was type B and one-fourth the children were type O and the rest were type B.

334. (3.00) All of the children were type A.

335. (3.00) The children were all type O.

336. (3.00) The father was type B, all of the children were type AB.

337. (3.00) The father was type A and children with each type of blood were born.

338. (3.00) The father was type A and among the children only three types of blood could be represented.

339. (3.00) Neither of the mother's parents could have been type AB.

340. (3.00) One-half of the children were type A and one-half of them were type O.

341. (3.00) All of the children were type B blood.

342. (3.00) In the fruit fly, gray body (B) is dominant to black body (b). Two gray flies are bred with each other and produce 158 grays and 49 blacks. The parents were

A. BB x BB. **B.** BB x Bb. **C.** Bb x Bb.
D. Bb x bb. **E.** bb x bb.

343. (3.00) A family is most likely to have a child afflicted with erythroblastosis fetalis if

- **A.** the father is Rh-negative and the mother is Rh-positive.
- **B.** the parents are Rh-positive.
- **C.** both parents are Rh-negative.
- **D.** the father is Rh-positive and the mother is Rh-negative.
- **E.** one or both parents have erythroblastosis fetalis.

344. (3.00) There is a breed of cats in which genes for black or white hair color do not show dominance or recessiveness. If a cat carrying only black hair color genes is bred to a cat carrying only white hair genes all of the offspring have gray hair. If two of these gray cats reproduce, their offspring would be expected to be

- **A.** all either all black or all white in no definite ratio.
- **B.** all gray individuals.
- **C.** one-half all gray individuals, one-fourth white, and one-fourth black.
- **D.** one-half all black and one-half all white.
- **E.** one-third each of black, white, and gray individuals.

There is a gene (C) for colored feathers in chickens that is completely dominant over gene (c) for lack of color. Chickens may also carry gene (I) which prevents gene (C) from exerting its effect and is completely dominant over gene (i) which allows color to develop normally.

For items 345 - 347 indicate according to the KEY what fraction of the offspring would be colored for each of the matings.

KEY

A. None colored. **B.** 1/16 colored.
C. 3/16 colored. **D.** 15/16 colored.
E. all colored.

345. (3.00) IiCc x IiCc.

346. (3.00) IICC x iicc.

347. (3.00) IICc x IiCc.

Items 348 - 350 are based upon the following situation:

You are the judge in a divorce court. A divorce case comes to trial in your court which involves a wife who is petitioning for support of both herself and a healthy, normal child of 10 months. The husband contends that he is not the father of the child and therefore should not be required to support it. The court orders blood tests with the following results:

Husband	Type O, Rh+, N.
Wife	Type AB, Rh−, N.
Baby	Type A, Rh+, M.

348. (3.00) You, as the judge, should conclude that the

- **A.** tests provide no evidence of significance in this case.
- **B.** husband in the case could have been the father of the child.
- **C.** husband could not have been the father unless someone other than the wife were the mother.
- **D.** man in the case may have been the father provided someone other than the wife were the mother.
- **E.** that the wife's background should be investigated further, because she could not be the mother under any circumstances.

349. (3.00) You, as the judge, reach the above conclusion because you know that (select the statement that provides the basis for your answer to item 348 above)

- **A.** an Rh− mother can never have an Rh+ child.
- **B.** an Rh+ child of an Rh− mother is feeble-minded or otherwise abnormal; this baby is normal, therefore could not be the offspring of the woman in the case.
- **C.** a person of type O could be the father of a type A child provided the mother has a gene for A antigen to contribute.
- **D.** a type N man could have a type N child if the mother were of type N or type MN.
- **E.** a type N wife could not produce a type M child, regardless of what type blood the father is.

350. In addition to the above conclusions you, the judge,
(3.00) would also know with certainty that the

- **A.** husband is not the father of the child.
- **B.** baby was heterozygous for the Rh factor.
- **C.** baby was heterozygous for Type A blood.
- **D.** father was homozygous for type A, Rh positive, and Type N.
- **E.** baby's mother was homozygous recessive for the Rh factor.

Item 351 deleted.

352. A family has seven sons. The theoretical probability that
(3.00) their eighth child will be a daughter is

- **A.** one chance in seven.
- **B.** one chance in eight.
- **C.** one chance in two.
- **D.** seven chances in eight.
- **E.** practically none.

353. Which one of the following illustrates what is meant by
(3.00) *eugenics?*

- **A.** The descendants of a shiftless backwoodsman included over 300 individuals who lived on public charity and 30 convicted criminals which cost the state more than $3,000,000.
- **B.** To help young people develop healthy bodies and keen alert minds, a certain community established playgrounds, municipal swimming pools and recreation centers which could be used without cost.
- **C.** A well-meaning wealthy man felt sympathetic toward a group of mentally defective people. Through his gifts of money these unfortunates were provided good homes, given simple jobs which they could do and were afforded opportunities to rear families like other more fortunate people.
- **D.** A young student in a university bordered on genius. He wished to marry a very intelligent girl but couldn't afford to do so. In recognition of his ability the university offered him a grant in money so he could continue his studies, marry this fine girl and begin rearing a family
- **E.** A gifted scientist gained such utter satisfaction from his success that in his eagerness to make more and more scientific contributions to humanity he shunned the responsibilities of marriage and the rearing of a family.

354. The simplest test of whether a pair of allelomorphs *A*
(3.00) and *a* is located on the sex chromosomes or on homologous autosomes is to

- **A.** compare the F_1 offspring of reciprocal crosses between an *A* strain and an *a* strain.
- **B.** determine the ratios among the F_2 offspring from a cross of an *A* strain to an *a* strain.
- **C.** compare the offspring obtained by backcrossing hybrids between *A* and *a* strains to the *A* strain, with those obtained by backcrossing to the *a* strain.
- **D.** to stain the chromosomes in dividing cells to determine whether one of the chromosomes is unpaired in one sex.
- **E.** discover whether the characters produced by the allelomorphs are evenly distributed between the two sexes or are segregated by sex.

355. Sex-linked inheritance of the sort found in Drosophila
(3.00) is likely to be found in any species in which

- **A.** the sexes are chromosomally determined.
- **B.** each individual produces both male and female gametes.
- **C.** the male is haploid, the female diploid.
- **D.** gametes produced by one sex are always of one type with regard to kinds of chromosomes while those produced by the other sex are of two types.
- **E.** gametes produced by both sexes are of two types with regard to kinds of chromosomes.

356. Characters must be transmitted by a single pair of genes,
(3.00) or allelomorphs, if they are

- **A.** characters whose degree of expression is quantitatively measurable.
- **B.** concerned with the fundamental metabolic processes common to all cells.
- **C.** characters subject to two qualitatively distinct modes of expression.
- **D.** dominant.
- **E.** None of the above is a critical test of whether the character is due to a single pair of alleles.

357. The total number of genes in every cell of an embryo
(3.00) (exclusive of any sex-linked genes) is

- **A.** equal to 1/n where *n* is the number of cells in the embryo.
- **B.** equal to the number of cells in the embryo.
- **C.** equal to 1/N where *N* is the number of organ primordia then present in the embryo.
- **D.** twice the number of genes in the unfertilized egg from which the embryo arose after fertilization.
- **E.** one half the number of genes in the unfertilized egg from which the embryo arose after fertilization.

Directions: For each of the following statements, *blacken* answer space

- *A* if it is true of *sex-linked* inheritance of the form found in Drosophila but not true of autosomal inheritance.
- *B* if it is true of *autosomal* inheritance but not of sex-linked inheritance of the form found in Drosophila.
- *C* if it is true of *both sex-linked and autosomal* inheritance in Drosophila.
- *D* if it is true of *neither* sex-linked *nor* autosomal inheritance in Drosophila.

358. The hereditary units which are transmitted from one
(3.00) generation to the next are found in the cytoplasm.

359. Independent segregation of hereditary units can occur
(3.00) within this type of inheritance during gametogenesis in males.

360. The F_1 hybrids from a cross of homozygous dominant
(3.00) mother with homozygous recessive father all resemble their mother.

361. The F_2 hybrids (from crossing F_1 with F_1) from an
(3.00) initial cross of homozygous dominant mother with homozygous recessive father appear in the ratio of ¾ dominant to ¼ recessive, phenotypically.

362. If you are sure of your answer in 361 blacken the
(3.00) same answer space for this item. If you are not sure of your answer in 361, blacken the answer space corresponding to your second choice.

363. The F_2 hybrids (from crossing F_1 with F_1) from an initial
(3.00) cross of homozygous recessive mother with homozygous dominant father appear in the ratio of ¾ dominant to ¼ recessive, phenotypically.

364. If you are sure of your answer in 363, blacken the
(3.00) same answer space for this item. If you are not sure of

your answer in 363, blacken the answer space corresponding to your second choice.

365 - 366. In the absence of antigen *A*, the blood plasma contains antibody *a*. This would react with any *introduced* cells of type A and cause them to clump together. Similarly, when antigen *B* is absent, the plasma contains antibody *b*, which causes clumping of *introduced* cells containing antigen *B*.

365. (3.00) A person whose parents both had type O blood could safely give blood by transfusion to persons with blood of type

A. O only. **B.** AB or O only. **C.** AB only.
D. A, B, or AB only. **E.** A, B, AB, or O.

366. (3.00) A blood transfusion is needed by a child whose parents were *both homozygous*, one for I^A, the other for I^B. Such a child can safely receive blood from a person of type

A. A only. **B.** B only. **C.** AB only.
D. A, B, or AB only. **E.** A, B, AB, or O.

367 - 368. Where gene I^A is present the blood cells contain antigen A, and where I^B occurs the blood cells contain antigen B. If neither of these genes is present, no antigens occur, and the blood is of type O.

367. (3.00) If one parent is of type A and the other of type B, their children might be of blood type

A. AB only. **B.** A, B, or AB, but not O.
C. A, B, or O, but not AB. **D.** O only.
E. A, B, AB, or O.

368. (3.00) If the parents are of type A and type O respectively, their children might be of blood type

A. A, B, AB, or O. **B.** A, B, or O, but not AB.
C. A or O, but not B or AB. **D.** A only.
E. O only.

369. (3.00) Human blood types A, B, AB, and O are determined by the presence of certain genes known as I^A, I^B, and i. Any given gamete can carry *only a single one* of these genes. Neither I^A nor I^B is dominant one over the other, but both are dominant over i. This is a case of

A. linkage and crossing-over. **B.** polyploidy.
C. chromosome deletion. **D.** multiple alleles.
E. chromosomal duplication.

370 - 374. From the key list below, select the correct phenotypic ratio which would be expected to occur among the offspring of a cross between two parents of the genotype AaBb under each of the conditions of gene interaction described in the following items.

KEY

A. 9 : 3 : 3 : 1. **B.** 9 : 7. **C.** 9 : 3 : 4.
D. 13 : 3. **E.** 15 : 1.

370. (3.00) Gene *A* is dominant to *a* and produces a visible effect. Gene *B* is dominant to *b* and produces no visible effect when present with *aa*, but when present with gene *A* modifies the effect that *A* produces alone. The absence of the two dominant genes produces no visible effect.

371. (3.00) Gene *A* is dominant to *a* and produces visible effect 1. Gene *B* is dominant to *b* and produces visible effect 2. The presence of genes *A* and *B* together produces both effect 1 and effect 2. The absence of both dominant genes produces no effect.

372. (3.00) Gene *A* is dominant to *a* and produces no visible effect. Gene *B* is dominant to *b* and produces no visible effect. But when genes *A* and *B* are present together, they produce a visible effect. The absence of both dominant genes produces no visible effect.

373. (3.00) Gene *A* is dominant to *a* and produces visible effect 1. Gene *B* is dominant to *b* and produces visible effect 2. The presence of genes *A* and *B* together produces visible effect 3. The absence of the two dominant genes produces no effect.

374. (3.00) Gene *A* is dominant to *a* and produces visible effect 1. Gene *B* is dominant to *b* and produces the same visible effect as gene *A*. The presence of genes *A* and *B* together produces the same effect as the presence of either one of them separately. The absence of both dominant genes produces no effect.

375. (3.00) The inheritance of skin pigmentation in man shows close similarities to the inheritance of

A. ear length in corn.
B. agouti coat color in mice.
C. walnut comb shape in fowls.
D. feather pigmentation in the Andalusian fowl.
E. lethal yellow coat color in mice.

376 - 379. Select from the key list of phenotypes of human skin pigmentation the correct answers to the following questions. Assume that skin pigmentation is controlled by two independent pairs of genes, that any dominant gene produces the same increase in pigmentation as any other dominant gene, and that the effect is additive.

KEY

A. black. **B.** dark brown. **C.** mulatto.
D. light tan. **E.** white.

376. (3.00) When a pure black individual is crossed with a pure white one, what will be the phenotype of their offspring?

377. (3.00) When two mulattoes are crossed, what is the lightest phenotype which could possibly occur among their offspring?

378. (3.00) When a mulatto is crossed with a white, what is the darkest phenotype that could possibly occur among their offspring?

379. (3.00) Any given phenotype may be produced by more than one genotype. Which phenotype can be produced by the greatest number of different genotypes?

380. (3.00) A type of abnormality in fowls caused by defective feathers is called frizzle, and is due to the action of a single pair of genes. When an extremely frizzled fowl is crossed with a normal one, all the offspring are mildly frizzled. In the F^2 the expected ratio would be

A. 3 normal to 1 extremely frizzled, because of complete dominance.
B. 3 extremely frizzled to 1 normal, because of complete dominance.
C. 3 normal to 1 mildly frizzled, because of lack of dominance.
D. 1 normal to 2 mildly frizzled to 1 extremely frizzled, because of complete dominance.
E. 1 normal to 2 mildly frizzled to 1 extremely frizzled, because of lack of dominance.

381. Extremely frizzled fowls also have increased metabolic
(3.00) rates, enlarged pancreases, and low fecundity. These phenomena are examples of

A. multiple effects of a single gene.
B. interactions of different gene pairs.
C. multiple-factor interactions.
D. effects of multiple alleles of one gene pair.
E. effects of several closely-linked genes.

382 - 388. In answering the following questions assume that gene *A* is *completely dominant* over gene *a*, that gene *B* is *completely dominant* over gene *b*, and that gene *C* is *completely dominant* over gene *c*. Further assume that each gene pair is located on a different chromosome pair.

382. The number of different kinds of gametes that an indi-
(3.00) vidual with the genotype AaBb can form is

A. 1. **B.** 2. **C.** 8. **D.** 4. **E.** 16.

383. Which one of the following sets of gametes can be
(3.00) formed by an individual with genotype Aabb?

A. Ab and aB. **B.** Ab and ab.
C. Ab, Ab, aB, and ab. **D.** Aa and bb.
E. Ab, ab, Aa, and bb.

384. The number of different kinds of gametes that an indi-
(3.00) vidual with the genotype AaBbCc can form is

A. 1. **B.** 2. **C.** 8. **D.** 4. **E.** 16.

385. The number of different *phenotypes* that can be found
(3.00) among the offspring of a cross between parents of genotypes AaBbCc and AaBbCc is

A. 32. **B.** 8. **C.** 16. **D.** 4. **E.** 64.

386. Of the numerous offspring produced by the cross given
(3.00) in #385, the fraction which will be phenotypically dominant for *any* two characters and phenotypically recessive for the remaining one will be

A. $\frac{1}{4}$. **B.** $\frac{1}{2}$. **C.** $\frac{9}{16}$. **D.** $\frac{3}{8}$. **E.** $\frac{27}{64}$.

387. Of the numerous offspring of a cross between parents
(3.00) of genotypes aaBb and Aabb, the fraction which will be genotypically AaBb will be about

A. $\frac{1}{4}$. **B.** $\frac{1}{2}$. **C.** $\frac{9}{16}$. **D.** $\frac{3}{8}$. **E.** $\frac{27}{64}$.

388. Of the offspring produced by the cross given in the
(3.00) preceding item (#387), the fraction which will be phenotypically A will be

A. $\frac{1}{4}$. **B.** $\frac{1}{2}$. **C.** $\frac{9}{16}$. **D.** $\frac{3}{8}$. **E.** $\frac{27}{64}$.

389. A certain female rabbit, possessing white subcutaneous
(3.00) fat, is mated to a male possessing yellow subcutaneous fat. All of the numerous offspring have white fat. The genotypes of the parents very probably are

A. both homozygous dominant.
B. both homozygous recessive.
C. both heterozygous.
D. one homozygous dominant, the other homozygous recessive.
E. one heterozygous, the other homozygous recessive.

390 - 393. A second female rabbit possessing white fat is crossed with two other male rabbits both possessing white fat. The offspring of the cross with male no. 1 are all white; the offspring of the cross with male no. 2 include some individuals with yellow fat.

390. The genotype of the female rabbit involved in these
(3.00) crosses very probably is

A. homozygous dominant. **B.** homozygous recessive.
C. heterozygous. **D.** either A or C.
E. not determinable because of insufficient evidence.

391. The genotype of male 1 very probably is
(3.00)

A. homozygous dominant. **B.** homozygous recessive.
C. heterozygous. **D.** either A or C.
E. not determinable because of insufficient evidence.

392. The genotype of male 2 very probably is
(3.00)

A. homozygous dominant. **B.** homozygous recessive.
C. heterozygous. **D.** either A or C.
E. not determinable because of insufficient evidence.

393. Of the many offspring produced by repeated matings
(3.00) of this female with a male possessing yellow fat, the fraction which would be expected to possess yellow fat would be about

A. $\frac{1}{16}$. **B.** $\frac{1}{8}$. **C.** $\frac{3}{4}$. **D.** $\frac{1}{4}$. **E.** $\frac{1}{2}$.

Domestic fowl exhibit four kinds of combs: single, rose, pea, and walnut. To obtain single comb both *R* and *P* must be absent, as in *rrpp*. *R* alone produces rose comb, *P* alone produces pea comb. Walnut comb is due to the interaction of *R* and *P*. *RRPP* is pure-breeding walnut comb. After each exercise number on the answer sheet, blacken the *one* lettered space which designates the correct answer.

394. A walnut-combed rooster when mated with single-
(3.00) combed hens begot numerous offspring, all of which had walnut combs. The most likely genotype of this rooster is

A. rrpp. **B.** RrPp. **C.** RRPp. **D.** RrPP.
E. RRPP.

395. A walnut-combed rooster when mated with single-
(3.00) combed hens begot 87 offspring. Forty-five of these had walnut combs and 42 had rose combs. The most likely genotype of this rooster is

A. RRPP. **B.** RRPp. **C.** RRpp. **D.** rrPP.
E. rrPp.

396. A walnut-combed rooster when mated with single-
(3.00) combed hens begot numerous offspring which had all types of combs. The most likely genotype of this rooster is

A. RRPP. **B.** RRPp. **C.** RrPP. **D.** RrPp.
E. rrPP.

397. If from among the offspring described in the previous
(3.00) question a walnut-combed rooster and a walnut-combed hen are selected and mated together, the most likely phenotype ratio of comb types among their offspring would be

A. 1 walnut : 1 rose : 1 pea : 1 single.
B. 3 walnut : 1 rose : 3 pea : 1 single.
C. 1 walnut : 1 single. **D.** all walnut.
E. 9 walnut : 3 rose : 3 pea : 1 single.

398. A pea-combed rooster and a pea-combed hen were
(3.00) mated together. Their offspring had two types of combs: pea and single. The most likely genotype of both these birds is

A. rrpp. **B.** Rrpp. **C.** rrPP. **D.** rrPp.
E. RRpp.

In the feather color of Andalusian chickens dominance fails with reference to feather color. The pure-breds are blue (BB) or white (bb); the hybrids are barred (Bb), that is with feathers both blue and white. The items are based on consideration of large numbers of offspring. After each item number on the answer sheet, blacken space

- *A* if blue is mated to white.
- *B* if barred is mated to blue.
- *C* if barred is mated to white.
- *D* if barred is mated to barred.
- *E* if more than one of the preceding categories applies.

399. All the offspring are barred.
(3.00)

400. One fourth of the offspring are blue.
(3.00)

401. One half of the offspring are barred.
(3.00)

402. One half of the offspring are white.
(3.00)

403. One half of the offspring are blue.
(3.00)

404. The actual count of all the offspring was 364 barred.
(3.00)

405. The actual count of all the offspring was 398 barred
(3.00) and 403 white.

406. The actual count of all the offspring was 502 blue and
(3.00) 497 barred.

407. The actual count of all the offspring was 199 blue, 402
(3.00) barred, and 203 white.

408. Two phenotypes appear in the offspring.
(3.00)

409. One phenotype appears in the offspring.
(3.00)

410. Three phenotypes appear in the offspring.
(3.00)

In the following diagram of guinea pig matings consider that enough matings between parents of identical heredity have been made to give the numbers of offspring indicated *in the parentheses*. Black (B) is dominant over white (b) and rough (R) is dominant over smooth (r). After the number on the answer sheet corresponding to that of each *numbered* phenotype, blacken space (All items are 3.00).

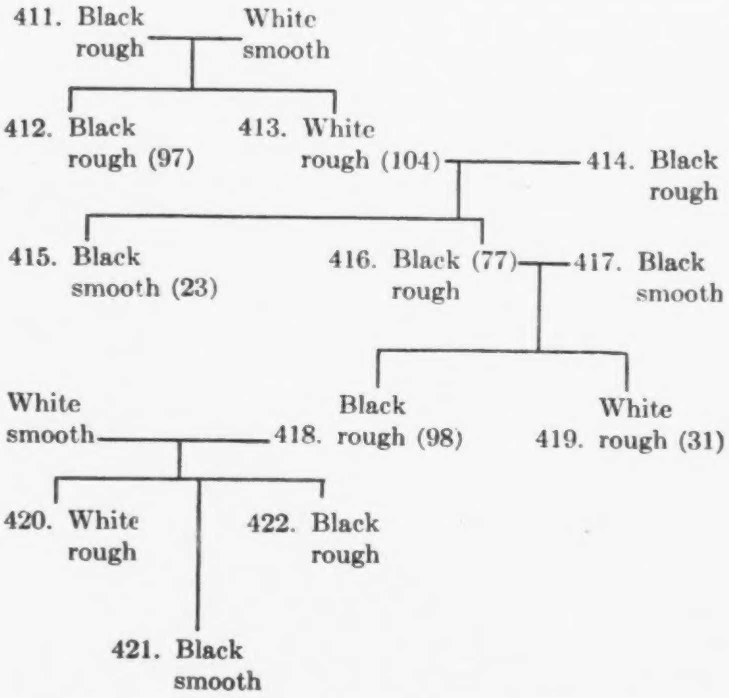
- **A.** if the genotype is BBRr.
- **B.** if the genotype is bbRr.
- **C.** if the genotype is BbRR.
- **D.** if the genotype is BbRr.
- **E.** if the genotype is Bbrr.

423. A plant of the genotype TtRr would produce the follow-
(3.00) ing types of gametes

A. Tt and Rr. **B.** TR and tr.
C. TR, Tr, tR, and tr. **D.** TR, Tr, and tr.
E. TtR, Ttr.

424. If Tall (T) is dominant, the progeny of the cross between
(3.00) a pure (homozygous) tall (TT) and heterozygous tall (Tt) would be

A. all tall. **B.** one-half tall and one-half dwarf.
C. one half tall and one half medium.
D. all dwarf. **E.** none of the above.



425. The snapdragon (which exhibits blending inheritance in
(3.00) the characters T and t for tall and short, and R and r for red and white) would appear short and pink with the genotype

A. ttRR. **B.** Ttrr. **C.** ttRr. **D.** ttrr.
E. TtRr.

In the five pedigrees below, three generations of individuals are represented. Squares represent males and circles females. An individual displaying the character is represented as a solid square or circle, while an individual not showing the character is represented by a blank square or circle. For items 426 through 428 blacken the answer space corresponding to the number of the appropriate pedigree. For items 429 and 430, blacken the answer space of the single best answer.

426. Which of the 5 pedigrees best shows inheritance of the
(3.00) character as a sex-linked recessive?

427. Which of the 5 pedigrees best shows inheritance of the
(3.00) character as a sex-linked dominant?

428. Which of the 5 pedigrees best shows inheritance of the
(3.00) character as an autosomal recessive?

429. Which of the 5 pedigrees best shows inheritance of the
(3.00) character as an autosomal dominant?

430. Which 2 pedigrees can be interpreted as showing in-
(3.00) heritance of the character as a sex-linked recessive?

A. 1 and 4. **B.** 2 and 3. **C.** 3 and 4.
D. 3 and 5. **E.** 4 and 5.

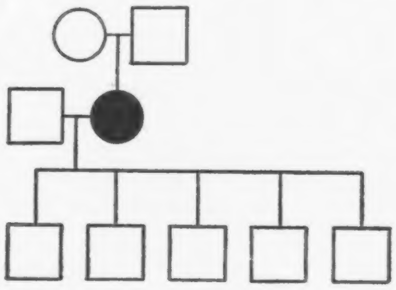
431. Which 2 pedigrees can be interpreted as showing in-
(3.00) heritance of the character as an autosomal dominant?

A. 1 and 4. **B.** 2 and 3. **C.** 3 and 4.
D. 2 and 4. **E.** 3 and 5.

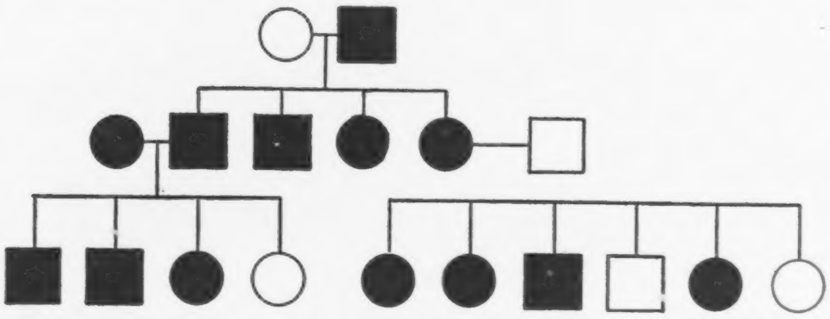
In summer squashes, white fruit is due to a dominant factor (W), and colored fruit to its recessive allele (w). As a result of matings, the offspring referred to in the items were obtained. After each item number on the answer sheet, blacken space

- *A* if the mating was heterozygous white x heterozygous white.
- *B* if the mating was heterozygous white x homozygous white.

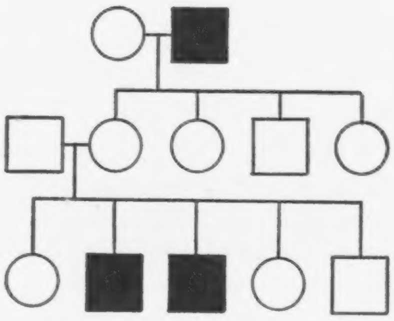
Pedigree 1



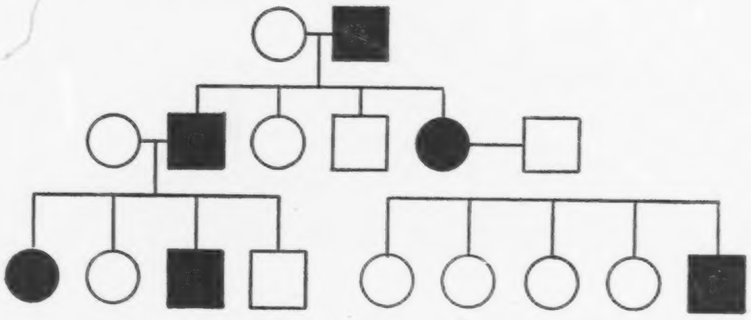
Pedigree 2



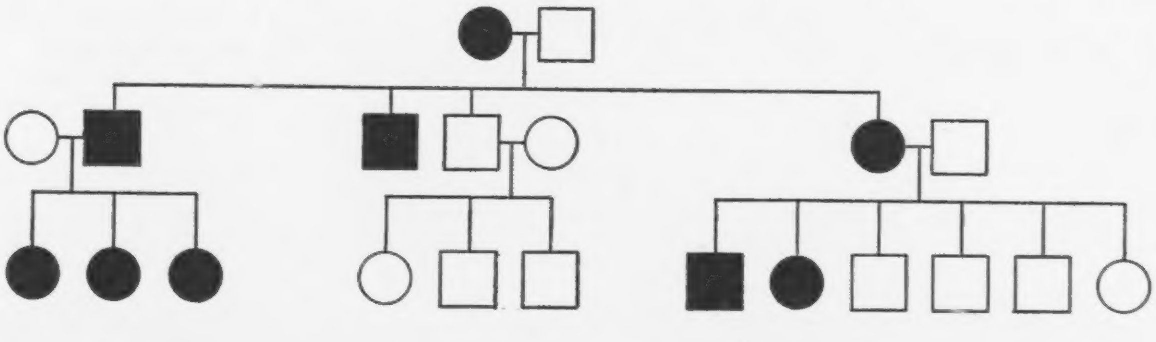
Pedigree 3



Pedigree 4



Pedigree 5



C if the mating was heterozygous white x homozygous colored.
D if the mating was homozygous white x homozygous colored.
E if the mating could have resulted from more than one of the preceding matings.

432. (3.00) All heterozygous white.

433. (3.00) One fourth colored.

434. (3.00) One half heterozygous white.

435. (3.00) One fourth homozygous white.

436. (3.00) One half colored.

437. (3.00) All white.

438. (3.00) All heterozygous dominant.

439. (3.00) Actual count: 298 white and 105 colored.

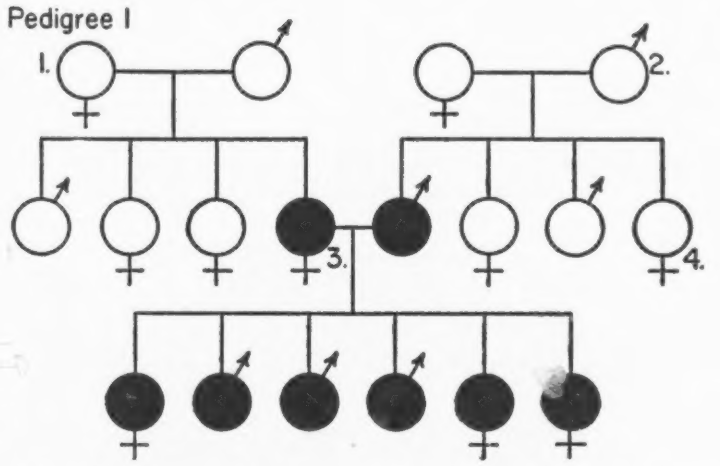
440. (3.00) One half homozygous recessive.

441. (3.30) One half homozygous dominant.

After each statement number on the answer sheet, blacken space

A if the statement is true and its truth is supported by evidence given in the diagram.
B if the statement is contradicted by evidence given in the diagram.
C if there is no evidence for determining whether the statement is true or false.

Note: The black symbols represent individuals possessing the character in question. Only one pair of alleles is involved and only two phenotypes.



442. The character represented here is probably a dominant
(3.00) character.

443. The character is definitely recessive.
(3.00)

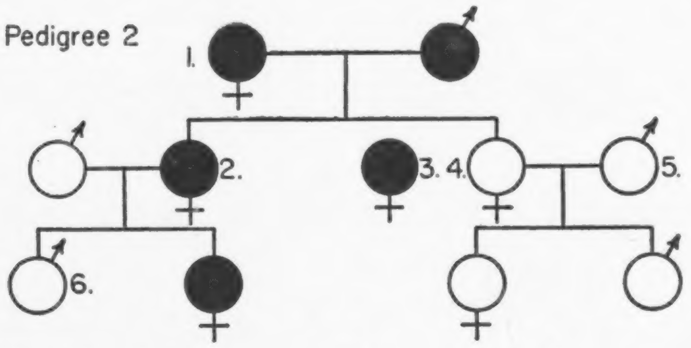
444. Individual number 1 is homozygous.
(3.00)

445. If the individuals number 2 and 3 were crossed, there
(3.00) would be a 50 per cent probability that their offspring would show the character.

446. Individual number 3 is heterozygous.
(3.00)

447. Individual number 4 is heterozygous.
(3.00)

448. The gene for this character is probably carried by the
(3.00) X-chromosomes.



449. The character represented here is dominant.
(3.00)

450. The character is recessive.
(3.00)

451. The gene for this character is carried by the X-chromosome.
(3.00)

452. Individual number 1 is heterozygous.
(3.00)

453. Individual number 2 is homozygous.
(3.00)

454. Individual number 3 is homozygous.
(3.00)

455. Individual number 4 is heterozygous.
(3.00)

456. If the cross between individuals number 4 and 5 had
(3.00) produced many more offspring there would be a greater chance of having some exhibit the character.

457. Which of the following is always true of a child that
(3.00) has erythroblastosis due to the mechanism of the Rh-factor?

- **A.** Its genotype is homozygous dominant for the Rh-factor.
- **B.** Its genotype is homozygous recessive for the Rh-factor.
- **C.** Its genotype is heterozygous for the Rh-factor.
- **D.** The child is unlikely to live more than a few hours after birth.
- **E.** None of the above is always true.

458. Which of the following is always true of an individual
(3.00) who has wavy hair?

- **A.** His parents were both heterozygous for the trait.
- **B.** All his children will have wavy hair.
- **C.** His phenotype is not readily apparent.
- **D.** His genotype cannot be determined without checking either his ancestry or his progeny, or both.
- **E.** None of the above is always true.

459. In fruit flies gray body (B) is dominant to black (b) and
(3.00) long wings (S) is dominant to short wings (s). When the mating BbSs x bbss occurs the progeny ratio turns out to be 50% black-bodied, short-winged and 50% gray-bodied, long-winged. Why were there no gray-bodied, short-winged or black-bodied, long-winged individuals among the progeny?

- **A.** According to Mendel's Law of Independent Assortment one would not expect these combinations to occur.
- **B.** Mutation had in all likelihood occurred.
- **C.** The gene for black body and the gene for short wings lie on the same chromosome.
- **D.** Half of the offspring died from lethal gene combinations.
- **E.** There is no way to account for this atypical phenomenon.

460. A red-green color-blind man marries a woman who is
(3.00) neither color-blind nor a carrier of the gene for the trait. Which one of the following statements would best describe their offspring?

- **A.** All of their male children will be color-blind.
- **B.** All of their female children will be color-blind.
- **C.** 50% of their male children will be color-blind.
- **D.** 50% of their female children will be color-blind and the other 50% will carry the gene for the trait.
- **E.** All of the female children will carry the gene for the trait but none will be color-blind.

In cattle, black coat (B) is dominant over red coat (b) and the hornless condition (H) is dominant over horned (h). A homozygous black horned male is mated with a homozygous red hornless female. These genes are neither linked nor sex-limited. Use the key list in answering items 461 - 463.

KEY

A. bbhh. **B.** BBHH. **C.** BBhh. **D.** bbHH.
E. BbHh.

461. What is the genotype of the male parent?
(3.00)

462. What is the genotype of the female parent?
(3.00)

463. What will be the genotype of the F_1 females?
(3.00)

464. A student carrying on experimental work in genetics is
(3.00) breeding Holstein-Friesian cattle. He knows from reliable hereditary records that for at least eight generations the cattle with which he is working have been black with white markings. The last calf to be born is marked with a red and white coat. He states that the calf is a mutant. Which of the following statements most nearly fits the situation?

A. If this animal were bred with a black and white animal and the offspring were all black and white, it would prove that the animal was not a mutant.
B. If another similar red calf were born in a herd somewhere else in the world it would prove his statement correct.
C. The student is reasoning from insufficient scientific data.
D. A character may skip several, but never more than five, generations.
E. The situation is quite improbable.

465. John Doe and Mary Roe were both afflicted with erythro-
(3.00) blastosis fetalis (Rh disease) at birth. If they married and had a child, what is the mathematical probability that their child would be similarly afflicted?

A. 0%. **B.** 25%. **C.** 50%. **D.** 75%. **E.** 100%.

466. In an orphanage the environmental conditions are quite
(3.00) similar for all the children. Studies of children reared in orphanages show that these children develop with as many differences as children growing up in their own homes. Other studies have been made which indicate that there is a closer correlation between the intelligence of parents and their own children than there is beween that of foster parents and their adopted children.

The chief problem discussed above is

A. What is the effect of orphanage life on personality?
B. Do dullards ever appear in favorable environments?
C. What influence do foster parents have on adopted children?
D. Can mediocre parents ever have a child of superior intelligence?
E. Is intelligence predominantly inherited or is it due primarily to environmental factors?

467. A chick and a duckling, both hatched in an incubator,
(3.00) were placed on the bank of a pond. Repeated observations all showed that the duckling would occasionally "take a swim" while at no time was the chick observed to be in water. The difference in behavior is best explained by which statement below?

A. The chick and duckling do not react positively to each other and consequently do not exhibit the same behavior.
B. The duckling has learned to swim while the chick has not.
C. The chick does not enter the water because if it did it would be drowned.
D. The inherited behavior pattern of the duckling is of such a nature that this animal reacts positively to the water.
E. The chick and duckling both inherit a behavior pattern which is identical as both animals are Aves and consequently related but the behavior of the chick is modified by the environment.

468. A large group of men, all normal for color vision, marry
(3.00) women each of whom carried one gene for color-blindness. They can expect color-blindness in

A. all of the children. **B.** one half of the children.
C. none of the children. **D.** all of the sons.
E. one half of the sons.

469. A man is blue eyed. His wife is homozygous for brown
(3.00) eyes. Which of the following, if any, is impossible?

A. No blue-eyed children.
B. No blue-eyed grandchildren.
C. No blue-eyed children as descendants of this pair for four generations.
D. No blue-eyed children appearing for 10 generations.
E. All of the above are possible.

470. A pure, dull-eyed, short-winged, yellow-bodied female
(3.00) fruit fly was crossed to a bright-eyed, long-winged, gray-bodied male. An F_1 female was backcrossed to a triply homozygous recessive male. The ratios of the offspring are as follows:

6/24 dull short yellow.
1/24 dull long gray.
3/24 dull short gray.
2/24 dull long yellow.
6/24 bright long gray.
1/24 bright short yellow.
3/24 bright long yellow.
2/24 bright short gray.

Give the order of these genes on the chromosomes.

---

471. Which of the following crosses would probably yield
(3.00) some completely homozygous recessives?

A. Ttrr x TTrr. **B.** TtRr x ttRR.
C. ttRR x TTrr. **D.** TtRr x ttRr.
E. TTrr x TTrr.

472. A pure red-eyed, forked-bristle female fruit fly was
(3.00) mated to a pure garnet-eyed, straight-bristle male. An F_1 red-eyed, straight-bristle female was crossed to a pure garnet-eyed, forked-bristle male. Of the offspring 1/6 were red straight, 1/3 red forked, 1/3 garnet straight, 1/6 garnet forked. What is the cross-over value between red and forked?

Note. In items 473 - 477, genes *A* and *a* are allelic (alternative) and autosomal. Genes *B* and *b* are allelic and autosomal and inherited independently of *A* and *a*.

473. Random combination of gametes in fertilization could
(3.00) be exhibited in the production of offspring by

A. AaBb x aabb. **B.** AAbb x aaBB.
C. AABB x aabb. **D.** Aabb x aaBb.
E. Aabb x aaBB.

474. If you are sure of your answer to 473, blacken the
(3.00) same answer space for item 474. If you are not sure of your answer to 473, blacken the answer space in 474 corresponding to your second choice.

475. The proportion of AbBb offspring to be expected from
(3.00) a cross of Aabb x aabb is________.

476. The proportion of AaBb offspring to be expected from
(3.00) a cross of AAbb x aabb is________.

477. Genes C and c are allelic and sex-linked. A, B, and C
(3.00) are each dominant to their alleles. The proportion of A-appearing, B-appearing, C-appearing male offspring to be expected from a cross of AABbCc x aaBbCc is ________.

In mice, several genes are known which in the homozygous condition actually kill the animal. The first case discovered was that of the peculiar yellow mouse, which always produces some black or gray young, as well as yellow. No pure-breeding yellow mouse has ever been found. Experiments have shown that matings of yellow with yellow produce on the average about ⅔ yellow and ⅓ non-yellow, and such litters are about 25 per cent smaller than normal. This was confirmed by the discovery of some 25 per cent of dead and disintegrating embryos within the pregnant mothers.

After the number on the answer sheet which corresponds to that of each of the following exercises, blacken the *one* lettered space which designates the *best* answer.

478. A gene, which in the homozygous condition kills the
(1.10) animal, is called

A. a lethal gene. **B.** a recessive gene.
C. a sub-lethal gene. **D.** an autosomal gene.
E. a holandric gene.

479. If a yellow mouse mated to a yellow mouse produces
(3.00) living offspring it can be assumed that the offspring are

A. all the same color. **B.** all the same phenotype.
C. all homozygous recessive. **D.** all heterozygous.
E. none of the above.

480. When non-yellow mice are mated, among the offspring
(3.00) there will be

A. ¾ yellow, ¼ non-yellow. **B.** all yellow offspring.
C. ¾ non-yellow, ¼ yellow.
D. half yellow, half non-yellow.
E. no yellow offspring.

481. In yellow mice, the dead embryos recovered from preg-
(3.00) nant mothers are

A. homozygous recessive.
B. homozygous dominant.
C. the genotype of the female parent.
D. the genotype of the male parent.
E. none of these.

482. If a mouse is yellow, it is known to be
(3.00)

A. homozygous recessive. **B.** heterozygous.
C. homozygous dominant. **D.** recessive mutant.
E. none of these.

483. The presence of yellow and non-yellow in the offspring
(3.00) of a yellow by yellow mating indicates that the parents are

A. both homozygous recessive.
B. both homozygous dominant.
C. one homozygous recessive, one heterozygous.
D. one homozygous dominant, one heterozygous.
E. both heterozygous.

484. Ephrussi's entire article is concerned primarily with
(2.20)

A. the location of the genes in the cells.
B. the transmission of characters from generation to generation.
C. the inheritance of metabolic traits.
D. an explanation of cell differentiation.
E. discrediting the Mendelian theories of heredity.

485. According to Ephrussi, the theoretical need for postu-
(2.20) lating the existence of cytoplasmic inheritance arises from

A. the reversibility of cell differentiation.
B. the ability of various parts of the early embryo to form complete embryos if isolated, but to form one whole embryo if left together.
C. the persistence of differentiation between several lines of cells with the same kinds of nuclei through repeated cell divisions.
D. the ability of one group of cells to become finally differentiated from another group and incapable of further cell division without differences appearing in the nuclear genes.
E. the fact that the egg and sperm contain cytoplasm as well as nucleus.

486. Suppose a character depended on a type of self-repro-
(3.00) ducing molecule which was present in *solution* in a given concentration in the cytoplasm. The offspring from crosses involving this kind of character would most likely

A. resemble their mothers.
B. resemble their fathers.
C. resemble whichever parent was dominant.
D. resemble whichever parent had the most of the molecule in his or her cytoplasm.
E. have the degree of this character exactly intermediate between the two parents.

487. In order to be sure that a hereditary trait is *not* due
(2.30) to a nuclear gene, one must be able to find

A. a particle in the cytoplasm which is paired in somatic cells, which divides equationally in cell division, and which segregates one to a germ cell.
B. no alternative to the trait existing in the species—that is, that the trait is common to all members of the species.
C. that in crosses between individuals differing in the trait, all offspring resemble the female parent.
D. that in crosses between individuals differing in the trait, the distribution of traits in the offspring could not be predicted on the basis of the behavior of chromosomes.

On page 3 Ephrussi states: "... The explanation of the gradual specialization of the different cell lines must be sought either (1) in terms of variation by means of mutation, sorting out, or intracellular selection of autonomous cytoplasmic components, or (2) in terms of specific responses of nuclear genes to local differences prevailing in the different regions of the egg cytoplasm, or (3) a combination of both mechanisms."

488. The "different cell lines" mentioned in the quotation
(3.00) refer to

A. clones of single-celled organisms derived from different parental cells.
B. the cells in male organisms on the one hand, and the cells in female organisms on the other.
C. the germ cell lines in organisms of different varieties or species.
D. the cells giving rise to different tissues in an embryonic multicellular organism.
E. all of the above.

489. If zygote should occur whose cytoplasmic components
(1.20) are evenly distributed throughout the cytoplasm, it could give rise to differentiated cells by the operation of

A. mechanism (1) but not mechanism (2).
B. mechanism (2) but not mechanism (1)
C. both mechanisms (1) and (2).
D. neither of the two mechanisms.

490. Self-perpetuating elements present in the zygote cyto-
(1.20) plasm are indispensable to the operation of

A. mechanism (1) but not mechanism (2).
B. mechanism (2) but not mechanism (1).
C. both mechanisms (1) and (2).
D. neither of the two mechanisms.

491. In accordance with Ephrussi's views, a hypothetical
(3.00) generalized line of cells could contain a certain number of autonomous cytoplasmic components, not essential to cell survival, the "sorting out" of which leads to the development of three different specialized lines of cells. The minimum number of such components necessary for this development is

A. one. **B.** two. **C.** three. **D.** eight.
E. none.

492. The usefulness of dispermic sea-urchin zygotes in estab-
(4.20) lishing that the chromosomes are the bearers of heredity is dependent on

A. the increase in the number of chromosomes relative to cytoplasm in such zygotes.
B. the tendency of embryos developing from such zygotes to resemble the paternal rather than the maternal parents.
C. the division of the zygote into four rather than two cells by the first cleavage.
D. the failure of some cells resulting from cleavage to receive all the kinds of chromosomes of the zygote.
E. the presence of unbalanced ratios of the various kinds of chromosomes in the daughter cells which receive a full complement of chromosomes.

493. The most conclusive evidence which could be given for
(4.20) Ephrussi's conclusion that the loss of respiratory enzymes in his "vegetative" mutants is not due to a mutation of a nuclear gene would be that

A. the loss is retained indefinitely in the course of vegetative reproduction.
B. in the mutation-producing solution, the mother cell remained normal while budding off mutant cells.
C. no enzyme-deficient offspring were produced from crosses between mutant and normal strains.
D. a cytoplasmic difference is observable between mutant and normal strains, when treated with an indicator substance in the "Nadi reaction."
E. the mutations occurred during the course of vegetative reproduction.

494. Ephrussi's best evidence for the particulate nature of
(4.20) the cytoplasmic component lacking in his "vegetative" mutants is that

A. a normal cell can bud off normal daughter cells after budding off mutant cells.
B. the enzymes lacking in the mutant cells are carried on the mitochondria.
C. the "Nadi reaction" stains some granules blue in normal cells but not in the mutant cells.
D. when a vegetative mutant is crossed with a segregational mutant, half the offspring are normal.
E. the rate of vegetative mutation can be increased artificially by treatment with certain chemicals.

495. The circumstance which best permits Ephrussi's tenta-
(4.20) tive identification of the blue granules stained by the Nadi reaction with the mitochondria is that

A. The Nadi reaction is a test for enzymes carried on the mitochondria.
B. The color is produced in granules rather than in the fluid part of the cytoplasm.
C. The enzyme responsible for the Nadi reaction is as likely to be in the fluid part of the cytoplasm as in the stained granules.
D. Any granular component of cytoplasm can duplicate itself without the directive influence of nuclear genes.

496. In order to identify the mitochondria as the autonomous
(4.20) cytoplasmic particles lost in Ephrussi's "vegetative" mutants, one must still demonstrate the truth of which one of the following unproven propositions?

A. The mitochondria carry the enzymes succinic dehydrogenase and cytochrome oxidase.
B. The granules stained by the Nadi reaction are mitochondria.
C. The activity of the mitochondria is uninfluenced by nuclear genes.
D. The self-duplication of the mitochondria is uninfluenced by nuclear genes.
E. The mitochondria are self-duplicating.

497. Cytochrome *c* is probably present in the mitochondria
(4.20) in yeast: Therefore the presence of cytochrome *c* in "vegetative mutant" as well as normal cells led Ephrussi to assume that

A. in the formation of vegetative mutants, the whole mitochondrion is not lost, but only the part concerned with the indophenol oxidase reaction.
B. the mitochondrion itself is not the self-duplication cytoplasmic particle, but its formation of certain enzymes is dependent on the particle.
C. in the vegetative mutant all the normal enzymes are present in the mitochondria but some are in an inactive state, due to abnormal nuclear activity.
D. several kinds of mitochondria, some carrying cytochrome *c* and others carrying succinic dehydrogenase, are present in normal yeast cytoplasm.
E. the mitochondrion carries enzymes involved in several different reactions.

498. The process of formation of "vegetative" respiratory
(4.20) mutants in yeast by itself lends support chiefly to Ephrussi's suggestion that cell differentiation can occur by

A. the segregation of a mixed population of plasmagenes.
B. the directed mutation of plasmagenes.
C. differential nuclear response to different local conditions.
D. all of the foregoing.
E. none of the foregoing.

499. It is important to Ephrussi's analogy between vegeta-
(4.20) tive mutation in yeast and cell differentiation that newly formed cells lack certain potencies as the result of an

environmental factor "without apparently affecting the totipotency of the generating cells," since Ephrussi must account for

- **A.** the ability of the differentiated cells to produce more cells by further cell division.
- **B.** the fact that many different kinds of cells are differentiated in a multicellular organism.
- **C.** the ability of differentiated cells to lose their differentiation in tissue culture and other experimental circumstance.
- **D.** the equal inheritance from both paternal and maternal parents.
- **E.** the retention of totipotency in the germ line.

500. (4.20) Ephrussi's reason for considering his "segregational" mutant to be due to a Mendelian *genetic* difference from normal yeast, is best given as follows:

- **A.** when the normal and mutant strains are crossed, the diploid cells appear normal.
- **B.** the ratio of normal to mutant spores produced by a hybrid between normal and mutant is 1 : 1.
- **C.** when the segregational mutant is crossed with the vegetative mutant, the diploid cells appear normal.
- **D.** the respiration deficiency persists throughout the course of an indefinite number of cell divisions.
- **E.** none of the foregoing.

501. (4.20) The aspect of the evidence from yeast which supports the view that cell differentiation can be due to the directed mutation of plasmagenes is:

- **A.** The results of crossing "segregational" and "vegetative" mutants demonstrate that a nuclear gene is necessary for the activation of a self-duplicating cytoplasmic unit.
- **B.** Genetic segregation in somatic cells could accomplish differentiation by the effect of different kinds of nuclei on the plasmagenes.
- **C.** The results of crossing "segregational" mutants demonstrate that a nuclear gene is responsible for the ability of a plasmagene to reproduce.
- **D.** Diploid cells resulting from the fusion of "vegetative" and "segregational" mutants are normal, so that a zygote would have potentialities lacked by either the egg or the fertilizing sperm.

502. (4.20) One of the possible reasons Ephrussi gives for the rarity of demonstrated cases of cytoplasmic heredity is that cytoplasmic heredity is concerned with fundamental cellular functions. This reason becomes relevant in view of the fact that

- **A.** fundamental cellular functions are closely similar in most of the organisms studied by biologists.
- **B.** most metabolic processes are directed by enzymes within the cytoplasm of cells.
- **C.** the mechanism of inheritance of a trait can be worked out only if an alternative trait exists.
- **D.** mitochondria are found in the cells of almost all living organisms.
- **E.** very few cytoplasmic particles are known to be self-duplicating and regularly transmitted during cell division.

503. (2.20) Sutton maintains that, if the genes are on the chromosomes, Mendel's purity of gametes is easily explained as due to

- **A.** synapsis during meiosis.
- **B.** the reduction division of meiosis.
- **C.** the equational division of meiosis.
- **D.** the presence of several genes on each chromosome.
- **E.** the permanent fusion of homologous chromosomes.

504. (2.20) Sutton realizes that, if the genes are on the chromosomes, Mendel's "independence of inheritance of distinct pairs of characters" must be the result of

- **A.** random orientation of the synapsed homologues on the reduction-division spindle.
- **B.** the separation of maternally- from paternally-derived chromosomes during meiosis.
- **C.** the existence of genes on one chromosome which are not allelomorphic to any of the genes on the homologous chromosome.
- **D.** the occasional shifting of the attribute of dominance from one allelomorph to the other.

505. (2.20) Sutton was moved to discard his initial idea that at reduction division all the maternal chromosomes pass to one pole and all the paternal chromosomes to the other after considering

- **A.** the process of meiosis in fish hybrids.
- **B.** Bateson's explanation of mosaics.
- **C.** the behavior of synapsed chromosomes on the equatorial plate.
- **D.** the number of chromosomes versus the number of heritable factors per cell.
- **E.** recombination inbreeding experiments.

506. (3.00) Sutton supposes that the number of different combinations of chromosomes possible in the gametes formed by an organism having *n* pairs of homologous chromosomes is

A. n^2. **B.** n^n. **C.** 4n. **D.** 2^n. **E.** $\sqrt{n}$

507. (3.00) Sutton supposes that the number of different kinds of combinations of gametes in uniting to form zygotes, if there are *N* kinds of sperms and *N* kinds of eggs is

A. N^2. **B.** N^N. **C.** 4N. **D.** 2^N. **E.** $\sqrt{N}$

508. (4.20) Sutton's explanation of the occurrence of true-breeding hybrids differs from Mendel's in

- **A.** postulating a variability of dominance relations between allelomorphs, while Mendel's did not.
- **B.** presuming that the hybrid was not a "true" hybrid, i.e., the sperm or pollen stimulated the development of the egg without contributing to the inheritance of the offspring.
- **C.** assuming that the number of chromosomes contributed to such hybrids by the father was unequal to the number contributed by the mother.
- **D.** asserting that such hybrids produced all pollen of the sort contributed initially by the paternal species, all eggs of the sort contributed initially by the maternal species.
- **E.** using the term "chromosome" instead of "character" or "formative element."

509. (4.20) A study of the phenomena of sex-linkage supports Sutton's hypothesis that the genes are parts of the chromosomes since

- **A.** genes are thus shown to be the mechanism of inheritance in species with separate sexes.
- **B.** the sex chromosomes are unusually large and visible during a greater period in meiosis than the other chromosomes.

C. the unusual mode of inheritance in sex-linkage is paralleled by the unequal distribution of the sex chromosomes between the sexes.
D. purity of gametes is best demonstrated with sex-linked characters.
E. random assorting of paternal and maternal chromosomes into the gametes can be demonstrated with the sex chromosomes.

Read the following selections carefully. They are taken from the article "Behind the Lysenko Controversy," by George Bernard Shaw. This article appeared in *The Saturday Review of Literature,* **32:10**, April 16, 1949.

Paragraph I:

Lysenko is a Russian biologist who believes that acquired characteristics are inherited. This goes back to the doctrine of Lamarck, and is in flat contradiction to the beliefs of western scientists, who trace their intellectual ancestry back to Darwin and Weismann. They deny that any acquired characteristic can be inherited. This point of view leads logically to a belief in determinism. Weismann was so fanatically determinist that he maintained that every act of a living creature was imposed on it by external circumstances. As Butler put it to Darwin, "Determinism banishes mind from the universe."

Paragraph II:

If you call this philosophical position fatalism rather than determinism, it becomes plain at once that it is a doctrine that no state can tolerate, least of all a socalist state, in which every citizen shall aim at altering circumstances for the better, purposely and conscientiously, and no criminal nor militant reactionary can be excused on the ground that his actions are not his own, but the operation of external nature forces, pre-determined from the beginning of the world, and entirely beyond his control or prevention. There is not a civilized country on earth which does not hold its citizens responsible for their conduct, persecuting ruthlessly all those who act irresponsibly, and in extreme cases certifying them as madmen and locking them up.

Directions: Items 510 - 516 are based on Paragraph II. Apply your knowledge of heredity and environment in answering these items. For each item mark space

A. if the statement is warranted.
B. if the statement is not warranted.
C. if the statement cannot be judged.

510. (4.20) Shaw is justified in implying that if we disbelieve in inheritance of acquired characteristics an individual is the victim of his heredity and can do nothing to improve himself, his development, and his way of life.

511. (4.20) One's heredity places certain limits beyond which an individual cannot develop.

512. (4.20) A divine power determines the degree to which an individual grows and develops.

513. (4.20) The character of any society is determined both by the genetic character of its citizenry and the nature of its physical conditions and resources.

514. (4.20) A democracy cannot survive since it involves a conflict between freedom of the individual and limitation of the individual by his heredity.

515. (4.20) Shaw is justified in implying that since no chance for change in individuals is conceivable on the basis of modern genetics, society must find the source of its survival in the circumstances of the environment and not in the nature of its individual citizens.

516. (4.20) Communism would have less incentive to offer its citizens to improve themselves and their way of life if it adopted a Weismannian rather than a Lamarckian point of view.

Paragraph III:

Lysenko is no determinist. Following up Michurin's agricultural experiments, he found that it is possible to extend the area of soil cultivation by breeding strains of wheat that flourish in a sub-Arctic climate, and transmit this acquired characteristic to the seed. This hard fact nullified Weismann and his determinism, as facts are continually nullifying paper theories and hypotheses.

Directions: Items 517 - 519 are based on Paragraph III. *Apply your knowledge of heredity and environment in answering these items.* For each item mark space

A. if the statement is warranted.
B. if the statement is not warranted.
C. if the statement cannot be judged.

517. (4.20) Different strains of wheat might possess characteristics which if combined in cross-breeding or isolated by selection would have the potentiality to withstand the sub-Arctic climate.

518. (4.20) No strain of wheat could be produced which would grow in a sub-Arctic region.

519. (4.20) Shaw offers proof that the cold-resistant characteristic is really an acquired characteristic.

Directions: In items 520 - 521 select the best answer and mark the corresponding space on the answer sheet.

520. (4.20) In the third paragraph, the last sentence is a statement that

A. is definitely established as true.
B. is not justified by the data in the paragraph.
C. is definitely contradicted by the data in the paragraph.
D. is partially contradicted by the data in the paragraph.
E. cannot be judged.

521. (4.20) In a later paragraph Shaw says: *"I cited the fact that, as breathing is an inborn habit, and speaking, like skating and bicycling, is one which every generation has to acquire, it proves that habits are acquired by imperceptible increments at each generation, the inborn habits being fully acquired, and the rest only in process of acquirement."* This is a conclusion that is

A. justified because of careful observation of his own acquired habits.
B. justified because he cites adequate facts.
C. justified because he presents adequate proof.
D. unjustified because the data are faulty or inadequate.
E. unjustified because no facts are presented.

The following set of items is concerned with the hair and the care of the hair. The items are based generally upon two selections. The first is taken from a college text-book of hygiene; the second from an advertisement. Read both selections carefully before proceeding to answer the items.

"The hair is perpetually falling out and growing anew. Because some hairs fall out, it is not to be concluded that the hair is necessarily growing thinner, for an equal number of new hairs may be taking the place of the old ones. The exchange of old hair for new takes place more rapidly in some than in others. There is also a difference in the rate of growth. The average rate is about a quarter to half an inch a month.

"In numerous unhealthy conditions of the scalp, hairs may fall out but not be replaced. When due to infection this may occur in limited areas. Ultimate regrowth depends upon whether the roots have retained their vitality.

"The male is susceptible to baldness, a trait which is apparently hereditary and sex-linked (i.e., appears only in one sex, in this case the male). Nothing whatever can be done to prevent it and little to check its progress. New hair cannot be regrown on areas denuded by this type of baldness. However, males are also subject to thinning of the hair from other causes and should not accept baldness as inevitable until they have consulted a dermatologist regarding the diagnosis and possibilities of treatment.

"Diffuse thinning of the hair is often, but not always, associated with dandruff.

"Dandruff is a communicable disease of the sebaceous glands of the scalp, which is thought to be communicable through articles (brushes, combs, hats) used in common with the infected. It occurs in two forms; in one form an excess of sebum collects on the scalp as a greasy deposit; in the other, as layers of dry scales which cause itching and are shed abundantly. The latter type is more common after childhood. No amateur methods of treating dandruff will do more than remove for the time being either the grease or the scales. A physician should be consulted both as to the diagnosis and the treatment. It is often not especially difficult to cure. Dandruff should be cured not only for its own sake but because it is sometimes related to a poor complexion and possibly to baldness.

"The nourishment of the hair comes entirely through the blood vessels at its root. Nothing applied to the scalp nourishes it except indirectly by improving local circulation. In most cases, brushing provides adequate stimulation of circulation. Many so-called hair tonics are alcoholic solutions that dissolve excess sebum and scales and improve the appearance of the hair temporarily. While these may do no harm, they may dry both the scalp and hair too much. Whenever it is suspected that medication is required, it should be prescribed by a physician for individual needs." (from *Hygiene*, F. L. Meredith, M.D., pp. 635-636. Blakiston Company, 1941.)

The following advertisement appears in certain daily newspapers with a wide circulation.

YOU CAN'T STOP HAIR GROWTH!
in a normal healthy scalp

(Presented here is a picture of an individual standing beside a chart of the cross section of the epidermis depicting a hair follicle and associated structures.)

B. W. McLean, Trichologist, explains hair growth process, using hair growth chart.

HAIR EXPERTS' SCIENTIFIC METHODS SPEED UP YOUR SCALP'S RETURN TO HEALTH MAKING IT POSSIBLE TO NOW OBTAIN

THICKER HAIR WITHIN 6 MONTHS

Your scalp like every human scalp, has a powerful, natural urge to grow hair. It is one of the basic bodily processes, and continues as long as the scalp remains normal and healthy. When hair stops growing, something has happened to interfere with this natural growth process. Our job is to find the cause, correct it, and repair the damage it has done.

JUST 3 STEPS TO SCALP HEALTH AND HAIR GROWTH

First, imbedded dandruff must be removed. Dandruff is dead scalp tissue and attracts decay organisms among which we often find *Pityrosporum ovale*, the villain of hair growth. This germ causes dandruff to become imbedded inside the tube through which hair grows. Beneath the scalp surface this microbacillus chokes hair growth, causes itchiness, excessive dryness or oiliness and, if not eliminated, finally baldness. HAIR EXPERTS' treatment using chemo-therapeutic methods, makes it possible to remove the infection and open the path for healthy hair growth.

Second, blood circulation must be normalized. The choking action of the dandruff germ upsets the circulation in the scalp. The microbacilli either enter, or block, the oil glands, these glands become infected, draw blood from the hair growing structure, and flood the scalp with excessive amounts of oil and pus. If blocked, the excessive dryness causes a lack of circulation throughout the scalp. The stimulating chemo-therapeutic action of HAIR EXPERTS' treatment rapidly balances blood distribution.

GROWING HAIR MUST HAVE BLOOD OUR METHODS STIMULATE CIRCULATION

Third, blood flow to source of hair growth must be stimulated. When the hair growing structure lacks circulation, malnutrition sets in. Malnutrition weakens any form of life and hair is no exception. Nature's powerful urge to grow hair loses its potency. Yet so strong is this urge that, in spite of less food, Nature does the best it can—it grows weaker hair. It is only logical, therefore, that, with the drawing of additional circulation to the scalp through HAIR EXPERTS' effective treatment, the hair growing structure is rejuvenated and the strong natural urge to grow strong, healthy hair is restored. New hair grows in more rapidly. Bare areas are covered. People formerly "old before their time" often acquire new attractiveness, a more youthful look, gain wonderful new self-confidence and seem to take on "a new lease on life."

YOUR HAIR IS A PRICELESS ASSET—DON'T LOSE IT—SEE US AT ONCE

We urge you, please do not delay—Follicle Shrinkage may set in, virtually ruining your hopes! Start treatments at once. You'll actually enjoy HAIR EXPERTS' treatments—briskly stimulating and refreshing—no heavy greasy salves used—pleasant as a shampoo—and administered by our friendly attendants in cheery private offices. Tear out this message now, for a reminder, and come in or phone us today for sure. Don't neglect your hair a day longer. Let's get acquainted and let's get started!

After reading the above selections, answer the following questions.

522. (4.20) The advertiser states that he will

- **A.** grow new hair on a bald individual.
- **B.** heal a scalp infected with a skin disease such as impetigo.
- **C.** prevent "follicle shrinkage."
- **D.** kill dandruff.
- **E.** stimulate circulation of the scalp.

523. (4.20) As far as can be determined from the advertisement, the advertiser is

- **A.** an M.D. general practitioner.
- **B.** a group of M.D. general practitioners.
- **C.** an M.D. specializing in hair growth.

D. a dermatologist (skin specialist).
E. none of the above.

524. The advertiser states
(4.20)

- **A.** how much thicker he will make the hair in 6 months.
- **B.** what he meant by a "normal" scalp.
- **C.** that he is able to find the cause (when hair has stopped growing), correct it, and repair the damage it has done.
- **D.** what his "advanced chemo-therapeutic method of treatment" is.
- **E.** when he believes hair becomes too oily.

525. According to the author of the hygiene text, dandruff
(4.20)

- **A.** is caused by an oily scalp.
- **B.** is a disease of the oil glands of the scalp.
- **C.** can be cured easily by the sufferer by the use of hair tonics.
- **D.** is the cause of certain types of baldness.
- **E.** is encountered in a serious form in the majority of cases immediately preceding baldness.

526. The advertiser can, according to the authors of the hygiene text,
(4.20)

- **A.** grow hair on any bald spot.
- **B.** stimulate hair growth in certain instances by mechanical means.
- **C.** stimulate the growth of hair that is present by the use of hair tonics.
- **D.** prevent malnutrition of the roots of the hair by feeding the roots with external applications of nutrient salve.

527. According to the author of the hygiene text, falling hair
(4.20)

- **A.** is a fairly good indication that one is becoming bald.
- **B.** is a definite indication that dandruff is present.
- **C.** takes place normally.
- **D.** shows that the scalp circulation is sluggish.
- **E.** indicates that there is an excess scalp oiliness.

528. According to the author of the hygiene text, hereditary baldness may be prevented by
(4.20)

- **A.** stimulating the circulation of the scalp.
- **B.** use of "advanced chemo-therapeutic means."
- **C.** getting rid of dandruff.
- **D.** destroying "*Pityrosporum ovale.*"
- **E.** none of the above.

529. The advertiser states that "Bare areas are covered." These areas are covered according to the statement,
(4.20)

- **A.** with hair combed over the bare spots.
- **B.** with hair grown on the bare spots.
- **C.** with a toupee.
- **D.** with a hair oil during treatment.
- **E.** the advertiser does not state with what they will be covered.

530. The sebaceous glands are
(4.20)

- **A.** the same as the sweat glands.
- **B.** a part of the shaft of hair itself.
- **C.** glands secreting onto the scalp through openings not connected in any way with the individual hairs nor with the sweat glands.
- **D.** found on the sides of the hair shaft within the dermis.
- **E.** glands found in the outer part of the epidermis.

531. The growing hair
(4.20)

- **A.** receives nourishment from the blood vessels surrounding the follicles.
- **B.** receives nourishment from material on the surface of the scalp.
- **C.** may be weakened through gentle massaging of the scalp.
- **D.** cannot be aided in its growth by maintaining a high level of general health.
- **E.** cannot be aided in its growth by the removal of dandruff.

23. Population Problems—Eugenics

POPULATION PROBLEMS — EUGENICS

True–False

1. (1.10) Decreased environmental pressure leads to increased reproductive potential.

True–False

2. (1.10) The world's food supply and its population are increasing proportionately.

3. (1.10) Competition is a greater factor in

A. interspecific relationships.
B. intraspecific relationships.

4. (1.10) Eugenics is

A. the science having to do with the betterment of living conditions to secure more efficient human beings.
B. the science which deals with reactions between antigens and antibodies in the blood stream.
C. the science which deals with the nature of diseases and their treatment.
D. the science which deals with influences that improve inborn or hereditary qualities of the human race.
E. a movement to insure human treatment of animals.

5. (1.20) In the human species the number of boys being born exceeds that of girls by 4 to 6 per cent. A reason would be that

A. Y-chromosome-bearing sperms fertilize more eggs than those sperms containing the X-chromosome.
B. since female embryos are weaker more female embryos are aborted.
C. more Y-chromosome-bearing sperms mature.
D. men, in general, are stronger than women.
E. more couples desire male offspring and follow practices that directly or indirectly increase the number of male babies born.

6. (1.20) An important miscalculation in Malthus' law of population was the fact that he

A. overlooked the possibility that war would limit the rate of population growth.
B. antagonized society by advocating scientific birth control.
C. underestimated the rate of growth of the world's population.
D. believed that public controls should be established over food production.
E. failed to take into account the ability of men to increase the rate of food production.

7. (1.20) A study of the population problems of the world reveals, at least with human populations, that

A. there is no correlation between birth rates and death rates.
B. countries with high death rates have low birth rates.
C. countries with high death rates have high birth rates.
D. countries with high death rates have low or high birth rates depending upon latitude.
E. birth rates are independent of countries or races.

8. (1.20) Which one of the following would be a *positive* eugenics measure?

A. Sterilization of all institutionalized feebleminded persons.
B. Enactment of laws preventing marriage of the insane, the feebleminded, and those who have venereal disease.
C. Segregation of the feebleminded, the insane, and those who have incurable diseases to prevent procreation of their kind.
D. Subsidizing marriages of persons having good heredity but low incomes.
E. Extension of facilities for improving the health and physical fitness of our adult population, thereby insuring that the next generation will inherit strong, healthy bodies.

9. (1.20) One solution to the problem of mental deficiency appears to be the sterilization of the mentally deficient. This procedure makes the individual incapable of reproduction

A. and unsexes the person so that the secondary sexual characteristics are soon lost.
B. by making the subject unable to participate in intercourse.
C. but able to participate in intercourse at first with a subsequent premature loss of this ability along with secondary sexual characteristics.
D. but able to enter into intercourse with no loss of secondary sexual characteristics.
E. by eliminating sexual impulses.

10. (1.20) Knowing that environments vary over long periods of time, what must happen within populations of organisms if such populations are to survive?

A. New species must be created.
B. The reproductive rate must increase.
C. Genera of such populations must cross breed with genera of another population.
D. The biotic potential must increase many-fold.
E. Suitable mutations must occur and be perpetuated.

11. (1.20) Galton in his study of the inheritance of height, considers that variation due to nurture is

A. properly the data of genetics, since acquired characters are inherited.
B. properly the data of genetics, since that science studies individual differences.
C. an extraneous factor which can be ignored, because statistically its effect on height is insignificant.
D. an extraneous factor which must be ruled out by experimental controls, i.e., by holding environment constant for persons with similar and different heredity.
E. not distinguishable from variations due to nature, there being no evidence at that time as to the relation between fluctuation and mutation.

12. (1.20) According to Galton, individual variations in members of the same family are due to

A. spontaneous (i.e., not caused by the environment) changes in the units of heredity.
B. random (i.e., unpredictable) changes in the units of heredity caused by the environment.
C. diverse changes in the units of heredity resulting from and corresponding to the slightly different environments to which different persons must adapt.
D. environmental effects on the soma and therefore not inheritable.
E. the fact that each individual is a random sample of his parents' store of hereditary units.

13. To which of the above alternatives would East apply
(1.10) the term "fluctuation"? (In item 12)

A. Alternative A.
B. Alternative B.
C. Alternative C.
D. Alternative D.
E. Alternative E.

14. To which of the alternatives in item 12 would the term
(1.10) "mutation" in the modern sense apply? (Select all correct alternatives.)

A. Alternative A.
B. Alternative B.
C. Alternative C.
D. Alternative D.
E. Alternative E.

15. It follows from Galton's notion of the cause of family
(1.20) likeness and individual difference that

A. individual cases cannot be predicted, although general laws as to relation between parents and offspring are possible.
B. there is no orderly relation between parents and their offspring.
C. if all environmental conditions could be held constant, prediction of individual offspring could be made.
D. if all environmental conditions could be controlled, all children of the same parents would be identical.
E. not all variations are inherited.

16. Galton uses the population as the unit in the study of
(1.10) inheritance because (select *all* correct alternatives)

A. populations remain the same from generation to generation.
B. closer approximation to his theoretical calculation of the 2 : 3 regression ratio can be made with large numbers.
C. random breeding is a necessary assumption in his argument.
D. his study of inheritance might have been preliminary to a consideration of evolution.
E. using statistical methods based on the laws of chance, average results can be predicted with great accuracy.

17. A population is defined most adequately by a measure
(1.20) of central tendency (M) and a measure of variation (Q) because

A. with these two measures it is possible to determine whether or not the distribution is normal.
B. the values are unaffected by random individual differences.
C. each individual's place in the population can be considered as a deviation from the mean.
D. normal distributions differ from each other only in their values of M and Q.
E. 50% of the population lie between ±1 Q from the mean.

18. A population can be defined in terms of M and Q only
(1.20) if the aspect of the population considered

A. varies from 0 to 100%.
B. can be analyzed into a small number of discrete classes.
C. is normally distributed.
D. can be treated as a continuous variable.
E. is present in at least one half of the members of the population.

19. Galton concludes that each parent contributes equally
(1.20) to the stature of their offspring. The evidence for the conclusion is that

A. the Q for offspring of like parents is less than Q for offspring of unlike parents.
B. the Q for offspring of like parents is the same as Q for offspring of unlike parents.
C. the M for offspring of like parents is less than M for offspring of unlike parents.
D. the M for offspring of like parents is the same as M for offspring of unlike parents.

20. This evidence (i.e., the statement you have selected in
(1.20) item 19) shows Galton that

A. height is an instance of blended inheritance.
B. transmutation of female measurements is justified.
C. offspring will be closer to the population mean than were the parents.
D. the height of offspring can be predicted from height of only one parent.
E. the average height of offspring will be one half the sum of the mother's height and the father's height.

21. At the outset Galton states that offspring receive
(1.20) less than 100% of their heritage from their parents. Galton would support this statement by pointing out that

A. human stature is not a simple element but composed of hundreds of parts, i.e., hereditary units.
B. each grandparent contributes a given fraction of the zygote nucleus.
C. in some characters, persons resemble their grandparents more than their parents.
D. cytology has shown that any particle of inheritance may be derived from any ancestor.
E. offspring of the same parents are different and therefore have different heredity.

22. Weismann holds that offspring receive
(1.10)

A. 100% of their heritage from their parents, ½ from each.
B. 100% of their heritage from their grandparents, ¼ from each.
C. 100% of their heritage from their great grandparents, ⅛ from each.
D. All three alternatives are true.

23. Galton's question then is how *much* less than 100% do
(1.20) parents contribute. An important step in the argument is the conclusion that the ancestral qualitative contribution to height is the average of the whole population. This conclusion is based on

A. the assumption that height is a blending character.
B. empirical measurements made by Galton on small groups from which he could estimate the true value.
C. the law of regression which shows that tall persons have smaller parents, still smaller grandparents, etc.
D. the argument that if height is an accidental factor in marriage, any person's remote ancestors constitute a large random sample of the population.

24. Knowing that ancestral contribution is average, Galton
(1.20) is finally able to conclude that offspring receive ⅔ of their inheritance from their parents. The conclusion depends on the following: (select all correct alternatives)

A. The assumption that if offspring received 100% of their heredity from their parents, the mean offspring would be identical to the mid-parent.

B. The empirical finding of a linear relationship between mid-parents and their average offspring, every point of which is (1) intermediate between these values and (2) twice as close to the parental stature as to population average.
C. The generalization that the mid-parental regression must be equal to ½ of the sum of the 2 parental regressions.
D. The assumption that the contribution of all progenitors can mix like various gases such that the total "pressure" of the mixture is a simple additive function of the partial pressures of the separate ingredients.

25. The average height of Englishmen is 69". If parents
(3.00) contribute 100% of the heritage of their offspring—in Galton's sense—the average height of the offspring of mid-parents 60" tall would be

A. 57". **B.** 60". **C.** 63". **D.** 66". **E.** 69".

26. In the same population (Mean = 69"), if the filial re-
(3.00) gression is ⅔, the average height of the offspring of mid-parents in the 60" class would be

A. 57". **B.** 60". **C.** 63". **D.** 66". **E.** 69".

27. The operation of natural selection would be more effec-
(1.20) tive in transforming a population if

A. there was no regression as in the case postulated in item 25.
B. there was regression as in the case postulated in item 26.

28. Mendel's approach to the study of inheritance differs
(1.20) from Galton's in that (select *all* correct alternatives)

A. Mendel sought an orderly or lawful relation between the appearance of parents and the appearance of their offspring.
B according to Mendel, there is no orderly relation between the appearance of parents and offspring and therefore the laws of heredity must be sought in the germ cells.
C. Mendel studied offspring-parent relations only under conditions in which the pedigree of the parents was carefully determined.
D. Mendel selected characters which presented only two discrete alternatives.
E. Mendel sought to predict the appearance of a particular individual offspring, not merely the probability of a certain kind of appearance.

29. Some of the alternatives to item 28 are not only im-
(1.20) proper answers to the question but are false statements when taken alone. For the present item, select *all* alternatives to item 28 which by themselves are *false* statements.

A. Alternative A. **B.** Alternative B.
C. Alternative C. **D.** Alternative D.
E. Alternative E.

30. Which statement below most completely describes what
(1.20) primarily determines the biotic potential?

A. Number of young that can be produced by each female.
B. Number of generations that can be produced in a given span of time.
C. Proportion of females in each generation.
D. Two of the above. **E.** All of the above.

31. A single bacterium allowed to multiply freely would
(1.20) produce 16 million bacteria at the end of eight hours. Which of the following normally prevents such a thing from happening?

A. Reproductive capacity. **B.** Evolution.
C. Environmental resistance. **D.** Natural selection.
E. Asexual reproduction.

32. If an individual wished to conduct a controlled experi-
(1.20) ment to study the effects of physical, chemical, and biological factors in the environment on large populations of organisms in a relatively short period of time he might find which one of the following most suitable for his study?

A. White rats. **B.** Human beings. **C.** Monkeys.
D. Dogs. **E.** Bacteria.

33. Which one of the following organisms goes through its
(1.20) life cycle free of competition and environmental resistance?

A. Lion. **B.** Eagle. **C.** Louse. **D.** Tapeworm.
E. None of these.

34. Which of the following is the only biological conse-
(1.20) quence of eugenic sterilization of a human being?

A. Modification of secondary sexual characteristics.
B. Loss of interest in the opposite sex.
C. Cessation of egg or sperm production in the body.
D. Cessation of sex hormone production.
E. Loss of procreative capacity.

35. Under natural conditions which one of the following
(1.20) kinds of organisms has the highest biotic potential?

A. Mankind. **B.** Bacteria. **C.** Elephants.
D. Whales. **E.** Orchids.

36. "It is better for all the world if instead of waiting to
(3.00) execute degenerate offspring for crime or to let them starve for their imbecility, society can prevent those who are manifestly unfit from continuing their kind. The principle that sustains compulsory vaccination is broad enough to cover cutting the Fallopian tubes."

—Chief Justice Oliver Wendell Holmes,
U. S. Supreme Court, 1926.

Of the problem alluded to in the above paragraph all are biological problems except which one?

A. Eugenic sterilization.
B. Capital punishment for crime.
C. Survival of the fittest by artificial selection.
D. Malnutrition. **E.** Immunization.

37. How does a colony of fruit flies in a one-pint bottle
(3.00) compare with a colony of the same kind of fruit flies in a half-pint bottle?

A. The environmental resistance is greater in the half-pint bottle.
B. The biotic potential is greater in the half-pint bottle.
C. The maximum colony size in the pint bottle will not exceed that in the half-pint bottle.
D. The maximum colony size will be reached within a shorter time in the pint bottle than in the half-pint bottle.
E. None of the above statements is true.

38. According to Hardy, the genotypic ratio of a random
(3.00) breeding population remains constant at the values expressed by: (select *all* correct alternatives)

A. $(p\ A + q\ a)^2$.
B. $p\ AA + 2\ q\ Aa + r\ aa$.
C. $p^2\ AA + s\ pr\ Aa + r^2\ aa$.
D. $p\ AA + 2\ pr\ Aa + r\ aa$.
E. $(p + q)^2\ AA + 2(p + q)(q + r)\ Aa + (q + r)^2\ aa$.

39. The frequency for gene A in the population $p\ AA +$
(3.00) $2\ q\ Aa + r\ aa$ (where $p + 2q + r = 100\%$) is

A. p. **B.** $\sqrt{p}$. **C.** p^2. **D.** $p + q$.
E. $\sqrt{p + q}$.

40. The important point made by Hardy is that the stable
(2.30) genotypic ratio will be obtained

A. in the first generation following random breeding.
B. in two generations where each has been produced by random breeding.
C. eventually under conditions of random breeding.
D. under conditions of random breeding when $q = 1 - q$.
E. when the gene frequency changes to a value such that $q^2 = pr$.

41. In order to compute the genotypic ratio in the genera-
(2.30) tion following random breeding, it is necessary to assume that the genotypic ratio among males and the genotypic ratio among females equal the genotypic ratio among the total population. This assumption is necessary because

A. only on this assumption will $q = 1 - q$.
B. Hardy's rule applies only if there is no selection; and if there is no selection, the genotypic ratio in both males and females will be identical to the genotypic ratio in the total population.
C. there cannot be random union of gametes if there are more male gametes than female gametes.
D. the Mendelian mechanism underlies the computation and according to Sutton, for each gamete containing a maternal chromosome, there will be another gamete containing the homologous paternal chromosome.
E. the first step in the computation requires postulating the probability of a male "A" gamete equals the probability of a female "A" gamete, both probabilities being the frequency of gene "A."

42. The frequency of gene "a" is r in which of the follow-
(3.00) ing populations?

A. $(p\ A + q\ a)^2$. **B.** $p\ AA + 2\ q\ Aa + r\ aa$.
C. $p^2\ AA + 2\ pr\ Aa + r^2\ aa$.
D. $p\ AA + 2\ pr\ Aa + r\ aa$.
E. $(p + q)^2\ AA + 2(p + q)(q + r)\ Aa + (q + r)^2\ aa$.

43. For the following items lettered A to F, *write* your
(2.30) answer in the space provided in the test booklet.

A. The frequency of gene "A" in the population 70% AA + 20% Aa + 10% aa is_______.
B. The frequency of gene "A" in the population 60,000 AA + 40,000 Aa + 20,000 aa is_______.
C. In a random breeding population, "B," the gene for black fur, is dominant; "b" for white fur is recessive. Four per cent of the species have white fur, the rest black fur. The gene frequency of "B" is _______.
D. What proportion of the population described in C has the heterozygous genotype Bb? _______.
E. Keeping in mind the reasoning required by item 41, Hardy's principle can readily be applied to a population in which the distributions of genotypes among males and among females are different. Let us assume the genotypic ratio among males is $\frac{5}{8}$ AA + $\frac{1}{4}$ Aa + $\frac{1}{8}$ aa, while the ratio among females is $\frac{1}{2}$ AA + $\frac{1}{4}$ Aa + $\frac{1}{4}$ aa. Now, if such a population bred at random and there was no mutation or selection, the stable genotypic ratio for the whole population would be_______.
F. The gene frequency for "A" in the stable population described in item E is_______.

44. It is clear that Hardy's rule as to the conditions neces-
(2.30) sary for a stable or unchanging genotypic ratio (refer to item 40) holds *in sensu strictu* only for a population of infinite size since

A. in a finite population absolute random breeding cannot be realized.
B. in any finite population q^r would never equal pr.
C. it would take an infinite amount of time for a finite population to reach stability.
D. in a finite population one allele or another would be favored and as a result q and $1 - q$ would never be identical.
E. $[q - (1 - q)]^2$, where q is the frequency of one allele, is a probability statement and is therefore only approximated by empirical "samples."

45. The *same* reasoning which leads to the conclusion that
(2.30) Hardy's rule holds strictly only for an infinite population, constitutes the basis for Mendel's argument that

A. the more plants examined, the closer the obtained ratio of dominant to recessive will approach 3 : 1.
B. it would take an infinite number of generations before inbreeding could eliminate heterozygosity.
C. union of the gametes of a hybrid are truly random only if the hybrid produces an infinite number of them.
D. plants must be selected in which the viability of hybrids is as high as the viability of the parents.

46. The reasoning which leads to the conclusion that
(2.10) Hardy's rule strictly holds only for a population of infinite size is put into mathematical terms by Wright, but Wright's argument can be stated non-mathematically as follows:

A. The variation in q from generation to generation is inversely related to the size of the population.
B. As there can be no selection relative to a gene if it is either fixed or absent, selection pressure contains the term $q(1 - q)$.
C. Only after a long series of generations will gene frequency be stabilized at a value which is determined by back and forth mutation rates.
D. In a large species the condition of random mating is never realized. There are two limiting cases of restriction of the probable mates of any given individual, each of which can be represented by mathematical models.

47. The effect of inbreeding on *gene frequency* can be com-
(2.30) pared with the case of random breeding by a consideration of Mendel's deduction of the genotypic ratios in a series of generations produced by self-fertilization.

It is clear from this deduction that, in the case of inbreeding,

A. the stability of gene frequency is reached only after many generations and is similar in this respect to random breeding.
B. the gene frequency is unaffected just as in the case of random breeding.
C. the gene frequency changes until all hybrids are eliminated and thus is different from random breeding.
D. the gene frequency is always changing and is therefore different from random breeding.

48. (2.10) The effect of recurrent mutation on q or gene frequency is as follows: [v is rate a → A; u is the rate A → a].

A. q will continue to change from generation to generation indefinitely at a rate expressed by $\frac{v}{u + v}$.
B. q will change from generation to generation until it equals the value $\frac{v}{u + v}$.
C. q will change from generation to generation until the mutation rate v equals the mutation rate u.
D. q will continue to change from generation to generation until one allele or the other is eliminated from the population.
E. q will change *only* if either u or v is zero—i.e., only if the mutation pressure is unopposed.

49. (2.10) The effect of selection on q or gene frequency is

A. different from the effect of mutation since selection, when taken alone, will change q to 0 or 1.
B. different from the effect of mutation, since selection will continue to change q indefinitely.
C. similar to effect of mutation in that both factors reduce $\triangle$ q to zero.
D. similar to effect of mutation in that both factors are directive; selection, when taken alone, usually acts like an unopposed mutation but it may produce stable equilibrium at a value between 0 and 1.
E. not simply related to the effect of mutation on q: like mutation, selection always changes q in a given direction but, on the other hand, it opposes mutation in the sense that if mutation alone increases q, selection would unalterably decrease q.

50. (2.30) A third factor which affects gene frequency is termed by Wright "the inbreeding effect." The existence of this third factor in any actual species can be deduced from the fact that

A. chance in part determines which gametes reconstitute the population.
B. adaptability in part determines which individuals will become parents.
C. closely related individuals have a greater chance of producing fertile offspring.
D. selection of mates is determined by considerations such as proximity, which amounts to saying that random breeding is never realized.
E. the larger the species, the more likely it is that some members will fail to produce offspring.

51. (2.30) The "inbreeding effect" changes q or gene frequency

A. according to the laws of probability.
B. in one direction until q = 0.
C. in one direction until q = 1.
D. in one or the other direction, depending on mutation and selection.
E. in one or the other direction, depending on the size of the population.

52. (2.30) On the average, the magnitude of the change in q brought about by the "inbreeding effect" is

A. a function of chance.
B. directly proportionate to mutation pressure.
C. inversely related to population size.
D. dependent on the species in question.
E. dependent on the particular gene in question.

53. (2.30) $\phi(q)$ is a function that expresses the simultaneous effects of all 3 factors. In the light of this function, consider the case of an extremely small population (using Wright's criterion for "small") in which the frequency of gene A is 95%. In the next generation the frequency of gene A is

A. more likely to be 98% than 92% only if AA individuals have a higher viability than Aa or aa individuals.
B. more likely to be 98% than 92% only if the mutation rate a → A is unopposed.
C. more likely to be 98% than 92% even if other factors are neutral.
D. equally likely to be 98% or 92%.
E. None of the above is true. It is impossible to make any kind of prediction in this case.

54. (2.30) The implication of this example is that in very small populations

A. q will keep on changing *ad infinitum*.
B. mutation pressure is more significant than selection.
C. the gene frequency in any one generation will not be identical to the equilibrium value, $\hat{q}$.
D. the frequencies of the most adaptive genes will increase until each one reaches 100%.
E. genes will become fixed irrespective of their survival value.

55. (2.30) $\phi(q)$ shows that encountering gene frequencies which are determined by selection is most likely in a population that is

A. small. **B.** intermediate. **C.** large.
D. large *in toto*, but is subdivided into numerous isolated medium-sized groups.

56. (2.30) If the difference between races is found to be the result of the values of q for several neutral genes, then the differentiation into separate races is most likely the result of

A. selection. **B.** isolation.
C. different mutation rates in the different races.
D. differences in the environments of the different races.

57. (2.30) Genetic variability or heterozygosity has the best chance of being maintained in a random breeding population that is

A. small. **B.** intermediate. **C.** large.

58. (1.20) The reason for your answer is that

A. the smaller the population, the larger the magnitude (on the average) of $\triangle$ q.
B. the smaller the population, the less is the effect of selection in eliminating mal-adaptive mutations.

C. in an intermediate population, neither does random differentiation proceed to fixation nor adaptive differentiation to equilibrium.
D. the larger the population, the more does it move about from peak to peak on the surface of adaptive values.
E. the larger the population, the closer it approximates the conditions in which predictions made on the basis of Hardy's rule would be exactly fulfilled.

59. (1.20) Of the alternatives in item 58, the statement which is false when taken by itself is

A. alternative A. **B.** alternative B.
C. alternatice C. **D.** alternative D.
E. alternative E.

60. (2.30) The simultaneous effect of all three factors on all gene frequencies is given by the function [ϕ (q_1, q_2 . . . q_n)] as a multidimensional surface in which harmonious gene frequencies would appear as peak values of $\overline{W}$ separated by valleys. A schematic representation of this surface is provided on the right. Consider this schema in answering the following two items.

A lowering of $\overline{W}$ (where $\overline{W}$ is the average of the adaptive values of all possible genotypes) corresponds with or is caused by (select *all* correct alternatives)

A. increased selection.
B. increase in genetic variability.
C. increase in mutation pressure.
D. increase in population size.
E. increase in the field of gene combinations occupied by a population.

61. (2.30) Under constant environmental conditions, a shifting about of the field of gene combinations occupied by a species is produced by or can be identified with (select *all* correct alternatives)

A. increased selection. **B.** decreased mutation.
C. fixation of genes irrespective of survival value.
D. small population size.
E. increase from medium to large population size accompanied with increased mutation.

62. (3.00) Consideration of a simple case in which there are only 2 genes, each with only 2 alleles, is a good way to illustrate the function ϕ(q_1, q_2, . . . q_n). Let us then assume a species in which height is affected equally by each of two genes. "A" and "B" each add 2 inches of height and each gene is allelemorphic to its absence —"a" and "b." If the last subtraction form (in East's sense) is 8 inches and the most adaptive size is 12 inches, then the best adapted genotypes are (select *all* correct alternatives)

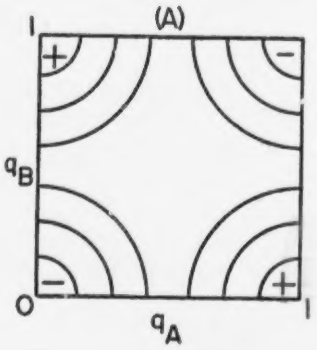
A. AABB. **B.** AAbb. **C.** AaBb. **D.** aaBB.
E. aabb.

63. (3.00) The number of peak values of $\overline{W}$ (when $\overline{W}$ is the average of the adaptive values of possible genotypes) in the case described in detail in item 62 (which may be represented by ϕ(q_A, q_B) is

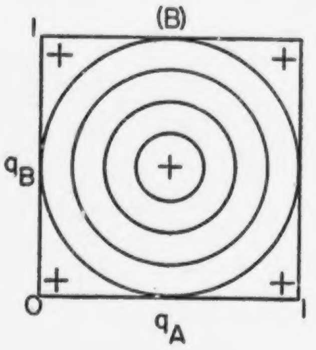
A. 1. **B.** 2. **C.** 3. **D.** 4. **E.** 5.

For items 64 and 65, the five alternatives consist of representations of ϕ(q_A, q_B) under different circumstances. For each item, you are to select the appropriate picture and blacken the answer space corresponding to the letter (A, B, C, D, E) of this picture. (Note that "+" is a peak, "—" is a valley.)

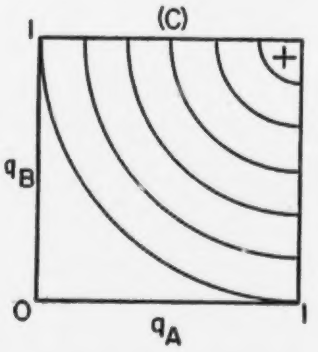
(A)



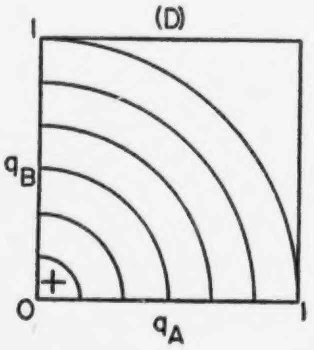
(B)



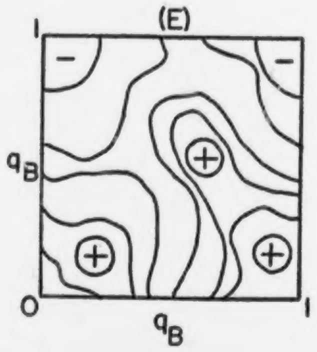
(C)



(D)



(E)



64. (3.00) The correct representation of ϕ(q_A, q_B) with the very same conditions described in item 62 is

A. A. **B.** B. **C.** C. **D.** D. **E.** E.

65. (3.00) Now let us assume that this same species described in item 62 finds itself in an environment which is changing. If, in the new environment, the taller the individual the better the adaptability, then the appropriate picture of ϕ(q_A, q_B) is

A. A. **B.** B. **C.** C. **D.** D. **E.** E.

66. (3.00) The typical creative research scientist in the U. S. A. has three children, or less, while the typical moron in the U. S. A. has nine, and often some of them are illegitimate. At this rate of increase, the former will have 27 greatgrandchildren, while the latter will have 729 greatgrandchildren.

Which of the following constitutes a valid appraisal of the above statement?

A With the advance of civilization the principle of the "survival of the fittest" still operates among mankind.
B. There is no cause for alarm in this—we need a large number of docile people, unable to do any original thinking, who will be content to do the many menial jobs in our society.
C. Our average national intelligence has been lowered each decade in the 20th century.
D. If we get too many intellectuals in the U. S. A., soon everybody will be out of a job.

E. Nothing should be done about this situation, for in a democracy we recognize absolute freedom of action for each individual.

Items 67 and 68 are based upon the following speech by Dr. Hugh H. Bennett, reported by James J. Murphy in the *Lansing State Journal,* June 27, 1948.

SAYS STARVATION THREATENS WORLD UNLESS LOSS OF SOIL IS PREVENTED

San Francisco (UP)—The chief of the United States government soil conservation service believes the United States—and the world—will begin literally to starve to death within 100 years unless human beings take better care of their soil.

Dr. Hugh H. Bennett, soil conservation director, told a luncheon here that only about 4,000,000,000 acres of land in the world are available for farming right now.

The world population is now a little more than 2,000,000,000 providing an over-all average of about two acres to feed every person.

But, Dr. Bennett pointed out, nutritionists have discovered it takes almost three acres to provide enough for a "minimum nutritional diet." To add to the already unbalanced situation, he said, world population is increasing at about 1 percent per year and available land is being constantly worn away by erosion, wasteful plowing methods, and inadequate care.

"It will do no harm at this critical period in our history," he declared, "to ask ourselves if the world could feed the 200,000,000 more people it will have in another 10 years at the present rate of increase."

Erosion, Bennett pointed out, already ranks among the top world causes of malnutrition, hunger and famine.

Japan, among other nations, is already in the dire straits the whole world might some day meet, he said. In Japan there is only about one-fourth of an acre per person to feed the population. China has only one-half acre, and India, one-third.

In 100 years, with the world's population doubled and granting that no more land is lost to erosion and other causes, there will be an average of only one acre per person in the world.

The United States is now in a comparatively enviable position, Bennett added, with a little more than three acres available for each of its 145,000,000 inhabitants.

But even here, he warned, the situation is growing worse each year. "In the last 150 years—especially in the last 100 years—half, or more of our American farm lands has been damaged, chiefly by erosion," he said.

"Originally, the topsoil in this country was nine inches deep. Now it is six inches deep," he added.

About 460,000,000 acres of crop-land is left, almost all of it subject to erosion, flood, and windstorm. The population is expected to continue increasing, creating a demand for 8,000,000 new acres of land every year.

"If it is assumed the same rate of population increase continues even for the next few decades," he warned, "we may be even closer to the danger line than we think."

67. The problem posed by Dr. Bennett is most inclusively
(3.00) expressed by which one of the following?

A. How can the American standard of living be raised?
B. How can the United States continue to maintain its present comparatively enviable position?
C. How can world-wide starvation – including the United States – be avoided during the next century?
D. Will the United States profit by the experiences of other countries?
E. How can Japan extricate herself out of her present dire straits?

68. The major adjustment which must be made to solve the
(3.00) problem is to

A. get more food from the sea.
B. develop chemical (soilless) agriculture.
C. build a stronger United States.
D. share food on a world-wide basis.
E. conserve the soil and take steps to limit world population increase.

Items 68 - 86 are concerned with growth of populations. They are based upon the curves and data on the following page as well as your laboratory study of this subject. For each item mark space

A. if the preceding data alone are sufficient to make the statement true or probably true.
B. if the preceding data alone are sufficient to make the statement false or probably false.
C. if the preceding data and/or other scientific knowledge make the statement true or probably true.
D. if the preceding data and/or other scientific knowledge make the statement false or probably false.
E. if neither the preceding data nor present scientific knowledge justify a decision as to the truth or falsity of this statement.

69. Communicable diseases have killed off a larger per-
(3.00) centage of the U. S. human population in the first 50 years of the present century than in any comparable period of time hitherto.

70. The population of the world more than doubled since
(3.00) 1840.

71. The world's population will double from 1960 to 2100.
(3.00)

72. The U. S. population increase is due, in part, to in-
(3.00) creased longevity.

73. The present world population is already too large for
(3.00) the potential world food supply; the upper limit of potential food production has already been reached.

74. During the past 100 years, improvement in genetic
(3.00) quality of the U. S. human population has paralleled the improvement in genetic quality of the finest livestock raised in the U. S.

75. Survival of the unfit in the human population is likely
(3.00) to occur to a greater extent in a highly civilized country than in a more backward country.

76. The increased efficiency in food production and dis-
(3.00) tribution which has occurred since 1800 will be dwarfed by the developments of science and the consequent world population increase during the next five centuries.

77. Man has done more than any other organism living on
(3.00) the earth to modify the ecological balance in nature.

78. Doubling the living space for a colony of fruit flies
(3.00) more than doubles the potential population of the same kind of flies that the space can support.

EFFECT OF ENVIRONMENT ON POPULATION INCREASE

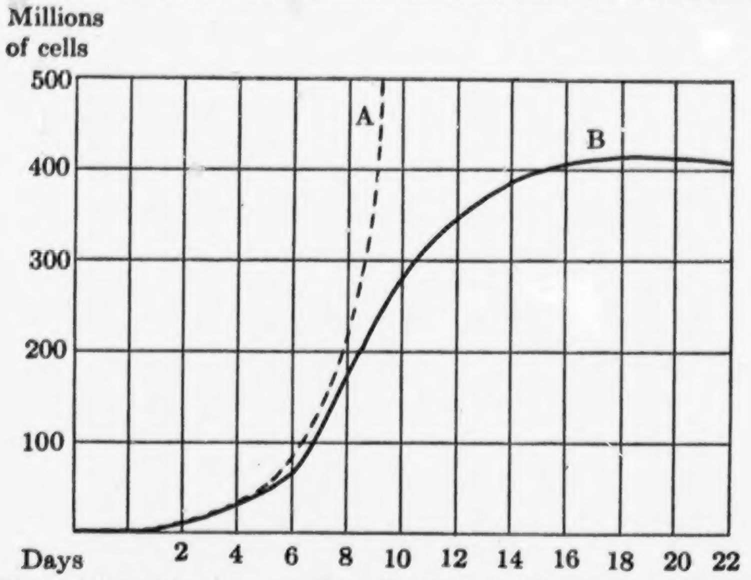


Fig. 1. Multiplication of yeast cells; horizontal axis, time in days; vertical axis, number of cells (in millions). A, theoretical rate of multiplication with unlimited space and food; B, actual rate of multiplication in a definite limited amount of nutrient solution.

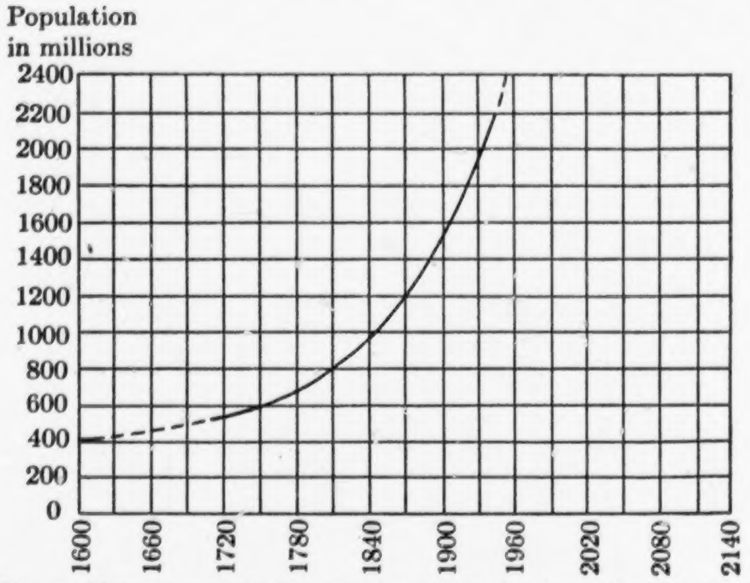


Fig. 3. Human population on the earth; horizontal axis, years; vertical axis, population in millions. The solid portion of the curve is based on actual data; the dotted portions are purely theoretical, calculated from the equation of the curve.

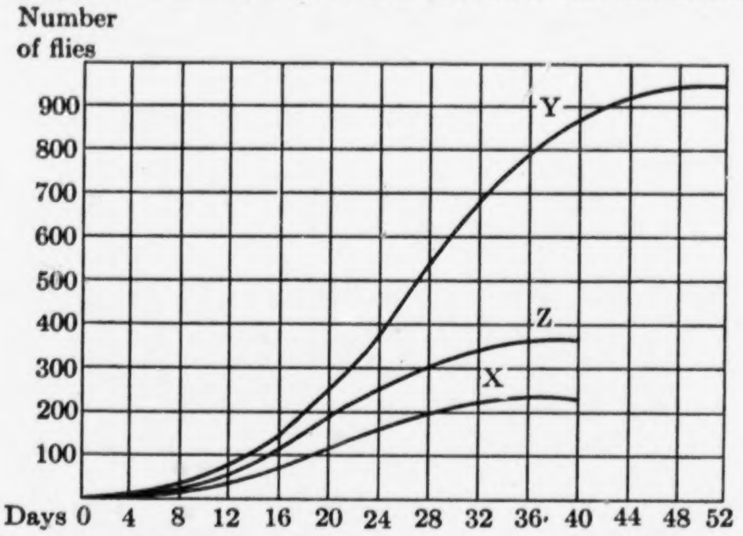


Fig. 2. Multiplication of Drosophila fruit flies; X, normal-winged strain in a half-pint bottle; Y, normal-winged strain in a one-pint bottle; Z, vestigial-winged strain in a one-pint bottle. Horizontal axis, time in days; vertical axis, number of flies.

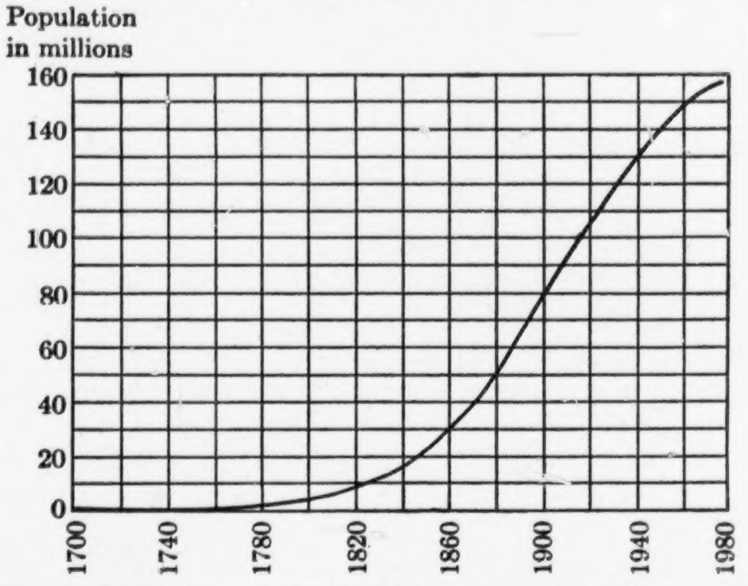


Fig. 4. Population of the United States from 1700 to 1950; horizontal axis, years; vertical axis, population in millions.

79. (3.00) By extending the earth's population curve it becomes apparent that within four or five centuries there will be so many people on the earth that they will have standing room only.

80. (3.00) If man could utilize his food resources to maximum efficiency, the growth curve of the world's population would resemble curve A for the yeast-cell colony increase.

81. (3.00) Vestigial-winged fruit flies are able to make more effective utilization of the living space available to them than is true of normal-winged individuals.

82. (3.00) The U. S. population curve will level off sooner than the world population curve.

83. (3.00) Normal-winged flies fully occupy the amount of space available to them in a 1-pint jar in a shorter period of time than do vestigial-winged flies in the same size of jar.

84. (3.00) By the 32nd day the death rate surpassed the birth rate in the vestigial-winged fly colony.

85. (3.00) The most rapid rate of increase in the U. S. population occurred between 1900 and 1920.

86. (3.00) Within the next five centuries the graph representing the world population will become bi-modal, that is, it will show a marked decline at some future date, followed later by a pronounced increase.

87. (3.00) Write a 500-word essay on *one* of the following:

A. Eugenic sterilization should be legalized in all forty-eight of the United States because—
B. Eugenic sterilization should be made illegal in every state in the United States because—

24. *Ecological Interrelationships*

ECOLOGICAL INTERRELATIONSHIPS

1. (1.10) The chief factor in the production of black or humus soils is the action of

A. running water. **B.** differential erosion.
C. bacteria on organic material.
D. cultivation and grazing. **E.** ground water.

2. (1.10) Frogs and toads are

A. key industry animals. **B.** herbivores.
C. saprophytes. **D.** ecological equivalents.
E. scavengers.

3. (1.10) Arctic foxes in the tundra and the hyenas in Africa are

A. key industry animals. **B.** insectivores.
C. top carnivores. **D.** ecological equivalents.
E. saprophytes.

4. (1.10) Vultures are

A. herbivores. **B.** green plants. **C.** carnivores.
D. scavengers. **E.** saprophytes.

5. (1.10) Mosses are

A. herbivores. **B.** green plants. **C.** carnivores.
D. scavengers. **E.** saprophytes.

6. (1.10) Bobcats are

A. herbivores. **B.** key industry animals.
C. carnivores. **D.** scavengers. **E.** saprophytes.

7. (1.10) A life-community is made up of the following groups:

A. insectivores. **B.** carnivores. **C.** scavengers.
D. green plants. **E.** saprophytes.

8. (1.10) Bread mold is

A. a symbiont. **B.** a scavenger.
C. an ecological equivalent. **D.** a saprophyte.
E. an herbivore.

9. (1.10) Nodule bacteria are

A. symbionts. **B.** scavengers. **C.** herbivores.
D saprophytes. **E.** parasites.

10. (1.10) Wheat rust is

A. a symbiont. **B.** a scavenger.
C. an herbivore. **D.** a saprophyte.
E. a parasite.

11. (1.10) Foods are spoiled by

A. symbionts. **B.** scavengers. **C.** herbivores.
D. saprophytes. **E.** parasites.

12. (1.10) Nitrogen from the air is added to the soil by

A. symbionts. **B.** scavengers. **C.** herbivores.
D. saprophytes. **E.** parasites.

13. (1.10) Symbiosis is represented by an association such as that involving

A. tapeworm and man. **B.** leather and mildew.
C. malaria organism and man.
D. termite and intestinal protozoa.
E. penicillium mold and cheese.

14. (1.10) An example of an herbivore is the

A. wolf. **B.** hawk. **C.** elephant.
D. adult frog. **E.** shark.

15. (1.10) A rattlesnake is an example of

A. a parasite. **B.** an herbivore. **C.** a carnivore.
D. a key industry animal. **E.** a saprophyte.

16. (1.10) The relationship between the two plants which constitute a lichen is known as

A. parasitism. **B.** saprophytism. **C.** symbiosis.
D. synthesis. **E.** homology.

17. (1.10) The disposal of sewage in a septic tank is accomplished mainly by the action of

A. bacteriophage. **B.** viruses. **C.** protozoa.
D. bacteria. **E.** rickettsias.

18. (1.10) Of the following zones of vegetation, the one found at the highest altitude is

A. coniferous forests. **B.** low herbs and shrubs.
C. mosses and lichens. **D.** deciduous forests.
E. palms and orchids.

19. (1.10) Xerophytes (cacti, sagebrush, etc.) have become adapted to their arid habitat by

A. evolving broad leaves to reduce transpiration.
B. evolving leaves much reduced in size with recessed stomata.
C. modification of their leaves to enable the plants to absorb moisture from the atmosphere instead of from the soil.
D. modification of the colloidal composition of their protoplasm to eliminate the need for water.

Items 20 - 24 deal with agencies responsible for the distribution of the plants listed in the questions. Indicate the agent which distributes each plant by marking

A. if the agent is the squirrel.
B. if the agent is birds.
C. if the agent is fur-bearing animals.
D. if the agent is the wind.

20. (1.10) Maple. **21. (1.10)** Wild Cherry. **22. (1.10)** Hickory.

23. (1.10) Poison ivy. **24. (1.10)** Burdock.

25. (1.10) Symbiosis is a situation in which

A. two species live in intimate association with benefit to both.
B. two species live in intimate association with one benefitted and the other neither benefitted nor harmed.

26. (1.10) The branch of biology dealing with the relationship between organisms and their environment is termed

A. cytology. **B.** limnology. **C.** ecology.
D. histology. **E.** pathology.

27. (1.10) Early man was prevented from making his home in northern Europe by

A. apes. **B.** lack of caves. **C.** glaciers.
D. land being covered by the sea. **E.** volcanos.

In items 28 - 32 some of the pairs are mutually beneficial or are dependent on each other, while other pairs are not. Mark

A. if the relationship is mutually beneficial.
B. if it is *not* mutually beneficial.

28. (1.10) The alga and the fungus in lichen.

29. (1.10) Mosses and grasses. **30.** (1.10) Bees and clover.

31. (1.10) Alfalfa and nitrogen-fixing bacteria.

32. (1.10) Elm trees and humming birds.

True-False

33. (1.10) Adjustment to changes in environment is called adaptation.

34. (1.10) Orderly changes in animal and plant species occupying the same habitat are termed

A. successions. **B.** migrations. **C.** zonations.
D. aggregations.

35. (1.10) *Two* organisms which live together for mutual benefit are spoken of as existing in which of the following relationships?

A. Abiogenetic. **B.** Parasitic. **C.** Saprophytic.
D. Symbiotic. **E.** Diastrophytic.

36. (1.10) "Lone wolves," as distinguished from socialized forms, are most common among the

A. arachnids. **B.** insects. **C.** amphibians.
D. herbivorous mammals. **E.** sponges.

37. (1.10) Some fixation of atmospheric nitrogen is accomplished by

A. a symbiotic relationship between an alga and a fungus.
B. certain bacteria living in the roots of leguminous plants.
C. leaves of green plants.
D. the roots of all higher plants. **E.** all of these.

38. (1.10) An animal community is made up of members which

A. are closely related to each other by evolutionary development.
B. are closely related to each other by environmental requirements.
C. have succeeded in killing off their competitors.
D. have similar nutritional requirements.
E. are all closely related structurally.

39. (1.10) Ecology is

A. the study of evolution. **B.** the study of fossils.
C. the study of disease.
D. the study of relation of animals to their environment.
E. none of the above.

40. (1.10) Nicotine, as used in the control of insects, is used usually as a

A. stomach poison. **B.** contact poison.
C. fumigant. **D.** repellant.
E. biological means of control.

41. (1.10) A *key industry organism* is characterized by which one of the following?

A. It is a plant possessing chlorophyll.
B. It is a vegetarian. **C.** It is a predator.
D. It is of relatively large size.
E. It is a non-green saprophytic plant.

42. (1.10) Which of the following is not an essential constituent of productive agricultural soil?

A. Air. **B.** Nitrogen. **C.** Chlorine.
D. Water. **E.** Bacteria.

43. (1.10) In order to grow soybeans on a sour acid soil it is most essential to add fertilizer containing which one of the following elements?

A. Nitrogen. **B.** Phosphorus. **C.** Potassium.
D. Iron. **E.** Lime.

44. (1.10) Hawks and owls are beneficial to man chiefly because they

A. constitute a source of food for carnivorous mammals.
B. feed upon insects. **C.** prey upon rodents.
D. make very fine museum and laboratory specimens.
E. constitute an important link in the evolutionary chain.

45. (1.10) Biotic potential is determined by

A. the number of young that can be produced by each female.
B. the number of generations that can be produced in a given span of time.
C. the proportion of females in each generation.
D. two of the above. **E.** all of the above.

46. (1.10) Higher plants generally absorb nitrogen from the soil in the form of

A. nitrogen molecules. **B.** urea. **C.** nitrates.
D. proteins. **E.** amino acids.

Item 47 deleted.

48. (1.10) Which of the following organisms is most numerous in the open ocean?

A. Blue-green algae. **B.** Fungi.
C. Brown algae. **D.** Diatoms. **E.** Bryophytes.

Item 49 deleted.

Items 50 - 56 deal with methods of obtaining water:

KEY

A. drinking.
B. in food.
C. by oxidation.
D. absorption of water through surface.

How do the following animals get most of their water supply?

50. (1.10) Frog. **51.** (1.10) Clothes moth. **52.** (1.10) Horse.

53. (1.10) Carpet beetle. **54.** (1.10) Meal worm.

55. (1.10) Man. **56.** (1.10) Desert lizard.

57. (1.10) The microscopic organisms living near the surface of water, either fresh or salt, are known collectively as

A. microbes. **B.** kelps. **C.** plankton.
D. blue-green algae. **E.** protozoa.

Items 58 - 62. In the mammals divergence into different habitats has been accompanied by adaptations in limb structure:

A. cursorial. **B.** fossorial. **C.** natatorial.
D. scansorial. **E.** volant.

What animal shows which of the above adaptations?

58. (1.10) Bat.

59. (1.10) Horse.

60. (1.10) Mole.

61. (1.10) Monkey.

62. (1.10) Seal.

63. (1.10) Ecology is the science of the

A. economic value of organisms.
B. development of organisms.
C. heredity of organisms.
D. nutritive value of organisms.
E. relationship of organisms to their environment.

64. (1.10) How do honeybees keep their hive near its usual temperature when outside temperatures are low?

A. by ventilation of the hive.
B. by evaporation of water.
C. by stopping work. **D.** by increasing insulation.
E. by increasing metabolism.

Items 65 - 72. The following percentages refer to the questions below:

A. 20%. **B.** 40%. **C.** 50%. **D.** 80%. **E.** 100%.

65. (1.10) What part of all living species is aquatic?

66. (1.10) What is the concentration of oxygen in air?

67. (1.10) What is the water content of a frog?

68. (1.10) What part of its water content may a frog lose and still survive?

69. (1.10) What would represent the decrease in pressure at an altitude of 20,000 feet?

70. (1.10) What would represent the increase in pressure at a depth of 30 feet in the sea?

71. (1.10) Increase in consumption of oxygen by an exotherm when the temperature is increased 5 degrees centigrade?

72. (1.10) What part of the earth's crust is made up of oxygen?

Items 73 - 79. Zoogeographical realms:

A. Palearctic. **B.** Oriental. **C.** Neotropical.
D. Nearctic. **E.** Australian.

73. (1.20) In which do we find native mammals such as the duckbill?

74. (1.20) Which of the other realms has more native marsupials?

75. (1.20) In which is New Zealand?

76. (1.20) Greenland?

77. (1.20) Europe?

78. (1.20) South America?

79. (1.20) Philippines?

80. (1.20) Animals at the top of a food chain

A. breed faster than those lower in the food chain.
B. are smaller than those lower in the chain.
C. are more numerous than those lower in the chain.
D. are carnivorous.

81. (1.20) The climate of a grassland region differs from that of a forest region in that the grassland receives less

A. moisture. **B.** light. **C.** wind.
D. extremes of temperature.

For items 82 - 86, blacken space

A. for that stage in the sand dunes succession which is the first to appear in the following series.
B. for the second in the series.
C. for the third in the series.
D. for the fourth in the series.
E. for the fifth in the series.

82. (1.20) Beech-maple association.

83. (1.20) Fore-dune association.

84. (1.20) Oak association.

85. (1.20) Pine association.

86. (1.20) Cottonwood association.

87. (1.20) Saprophytes are important because they

A. cause disease. **B.** are parasitic on plants.
C. convert organic substances into materials unavailable to other organisms.
D. convert organic materials into materials available to organisms.
E. prevent food spoilage.

88. (1.20) Which of the following species of animals is likely to be found over a wider range of climatic conditions than any of the others?

A. Fox. **B.** Snake. **C.** Salamander.
D. Frog. **E.** Alligator.

89. (1.20) The climax stage of a biotic succession

A. persists until the environment or climate changes.
B. changes rapidly from time to time.
C. is the first stage in a succession.
D. is the stage in which only plants are present.
E. varies considerably regardless of the climate.

90. (1.20) The primary needs of any individual in a community are

A. photosynthesis and digestion.
B. reproduction and food.
C. reproduction and excretion.
D. food and shelter.
E. shelter and reproduction.

91. The sequence in a typical food chain is
(1.20)

A. plants—large carnivores—small carnivores—herbivores.
B. plants—herbivores—small carnivores—large carnivores.
C. large carnivores—small carnivores—herbivores—plants.
D. herbivores—plants—large carnivores—small carnivores.
E. small carnivores—large carnivores—herbivores—plants.

92. Four of the following conditions are necessary requirements before seeds will germinate. Which one is *unnecessary?*
(1.20)

A. A sufficient supply of water.
B. A favorable temperature (50° to 80°F.).
C. A supply of oxygen.
D. An adequate amount and intensity of light.
E. The seeds themselves must be viable.

93. Which one of the following is an example of dynamic equilibrium?
(1.20)

A. A glacial boulder balanced on a mountain pinnacle.
B. The atmosphere.
C. The composition of the blood.
D. The fossils of organisms which have lived on the earth in past ages.
E. An apparatus consisting of a beaker of water, a thistle tube, molasses, and non-waterproof cellophane, set up to demonstrate osmosis.

94. A biological community is
(1.20)

A. made up of organisms all of which are closely related.
B. made up of organisms which cooperate closely with each other to insure the maximum survival of all species within the group.
C. made up of organisms which are adapted to the physical conditions prevailing there.
D. made up of organisms which live more or less independently of each other.
E. a non-existent entity—there is no such thing.

95. When the plant succession reaches its climax, it may be driven back to an earlier stage by
(1.20)

A. fire. **B.** invasion by annual weeds.
C. a wetter climatic cycle.
D. invasion by briars and brush. **E.** all of these.

96. We are listing the beneficial aspects of fungi. Which of the following should *not* be included in our list?
(1.20)

A. Fungi contribute to soil fertility.
B. Fungi are unusually efficient in the process of photosynthesis.
C. Fungi produce antibiotics such as penicillin and streptomyecin.
D. Fungi are an increasing source of protein for feed industries.

97. Soil factors which may affect the ecological distribution of plants include all *except* which *one* of the following:
(1.20)

A. available water in the soil.
B. temperature of the soil. **C.** air in the soil.
D. quantity and nature of solutes dissolved in the soil.
E. light penetration into the soil.

98. In the following pair, blacken space A if the first element of the pair is definitely greater than the second; space B if the second is definitely greater than the first; and space C if the two are approximately equal.
(1.20)

A. Number of rabbits in a food web.
B. Number of foxes in the same food web.

99. Which one of the following groups of animals tends to become immobilized by a temperature of 30°F.?
(1.20)

A. Reptiles. **B.** Birds. **C.** Carnivorous mammals.
D. Herbivorous mammals.
E. Omnivorous mammals.

100. Biological control is not always successful because
(1.20)

A. the interrelations of organisms in a community are very complex and it is difficult to know what the introduction of a new form will do.
B. insects often become immune to sprays, the spray being effective at first but gradually becoming less and less so.
C. effective sprays are often difficult to secure in large quantities.
D. it often happens that no effective spray can be developed for the insect in question.
E. not all insects have the same type of mouth parts.

101. Of the following the ultimate source of all food in the typical freshwater pond is/are the
(1.20)

A. microscopic green plants.
B. minute unicellular animals.
C. minnows, aquatic insects, and molluscs.
D. large water weeds.
E. bacteria and fungi.

102. Of the following which one would be best to plant for the purpose of restoring nitrogen to the soil?
(1.20)

A. Rye. **B.** Wheat. **C.** Soy beans.
D. Corn. **E.** Timothy hay.

103. In an ecological food chain a *key industry organism* is characterized by which one of the following?
(1.20)

A. It is a plant possessing chlorophyll.
B. It is a vegetarian.
C. It is a predator.
D. It is of relatively large size.
E. It is a non-green saprophytic plant.

104. Which of the following occurs in the normal course of plant succession?
(1.20)

A. Grasses follow brush and briar.
B. Annual weeds follow grasses.
C. Shade-tolerant trees follow briar and brush.
D. Shade-tolerant trees follow light-requiring trees.

Item 105 deleted.

106. If the following organisms constitute a food chain, which organism would be at the top or apex of the so-called pyramid of numbers?
(1.20)

A. Hawk.
B. Fox.
C. Corn plant.
D. Mouse.
E. None of the above.

107. Certain termites eat wood but are unable to digest the wood without the aid of flagellate protozoans which live in their intestines. The protozoans are in turn un-
(1.20)

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able to live outside the bodies of termites. This is an example of

A. commensalism. B. slavery. C. parasitism.
D. symbiosis. E. saprophytism.

108. Animals are dependent upon green plants for their food
(1.20) supply. Some green plants in turn are dependent upon certain

A. molds. B. bacteria. C. algae.
D. protozoa. E. viruses.

Items 109 - 114 are concerned with interrelationships between organisms and their habitats. For each item select from the key the North American plant habitat which is ecologically associated with the animal population listed in the item.

KEY

- A. Bog mosses, lichens, sedges, grasses, low herbs.
- B. Spruces, firs, pines, cedars, white birches, occasional grasslands.
- C. Oaks, maples, beeches, elms, walnuts.
- D. Great areas of hardy grasses, trees along streams only.
- E. Vegetation scattered, cacti, yuccas.

109. White-tailed deer, wildcat, fox, raccoon, flying squirrel,
(1.20) warblers, vireos, many snakes and amphibians.

110. Moose, certain caribou, deer, elk, fox, wolverine, some
(1.20) small rodents, grouse, few reptiles and amphibians.

111. Antelope, wolf, coyote, badger, skunk, jack rabbit, bur-
(1.20) rowing owl.

112. Musk ox, wolf, fox, weasel, certain hares and caribou,
(1.20) reindeer, mosquitoes. No reptiles.

113. Few birds, many lizards, some snakes, few amphibians.
(1.20)

114. Mink, beaver, black bear, wolves, partridge, hares.
(1.20)

115. The *key industry animal,* among the following, would
(1.20) probably be the

A. robin. B. earthworm. C. weasel.
D. eagle E. fox.

116. In temperate latitudes the beech-maple forest is suc-
(1.20) ceeded by the

A. oak forest. B. pine forest.
C. cottonwood forest.
D. none of the above forests.

117. A designated niche (habitat) in a community can be
(1.20) occupied in another community by

A. members of different species.
B. members of the same species.
C. members of the same or different species.

118. In the ocean depths, the most important factor that
(1.20) limits plant life is

A. light. B. salts. C. carbon dioxide.
D. none of the above factors.

119. Key industry animals (that is the animals at the bottom
(1.20) of the "food pyramid") include

A. foxes. B. rabbits. C. owls.
D. parasitic protozoa.

120. The competitors of carnivores are
(1.20)

A. other carnivores. B. herbivores.
C. other animals of the same size.
D. none of the above types of animals.

121. In a designated habitat the number of carnivores exceeds
(1.20) the number of

A. saprophytes. B. parasites. C. herbivores.
D. none of the above.

122. A mammal that is typical of the tundra is the
(1.20)

A. elephant. B. deer. C. musk-ox.
D. raccoon.

123. Commensalism involves a relationship in which
(1.20)

A. an organism feeds on the tissues and organs of another living organism.
B. the host neither benefits nor is harmed by the presence of the guest.
C. an organism obtains its food from the dead bodies of other organisms.
D. both host and guest benefit from the presence of the other.

124. Pelagic communities of the ocean are found
(1.20)

A. in the open sea and not at the bottom.
B. at the margin of the sea on the bottom.
C. at great depths of the sea and on the bottom.
D. in none of the above locations.

125. An inclusive natural habitat of wide geographic range
(1.20) that is made up of characteristic fauna and flora is the

A. environment. B. zone. C. community.
D. biome.

126. An ecological series that displays orderly changes of the
(1.20) biotic constitution in a habitat exemplifies

A. succession. B. biome. C. environment.
D. a climax.

127. Which of the following practices would *not* help to
(1.20) conserve soil?

A. strip cropping.
B. planting of crops in horizontal rows around a slope.
C. terracing.
D. planting crops in rows running up a slope.

128. Climatic factors affecting plant growth include all *except*
(1.20) which *one* of the following?

A. Temperature. B. Light.
C. Carbon dioxide concentration.
D. Bacteria on suspended dust particles in the air.
E. Atmospheric humidity and precipitation.

129. Which of the following environmental factors affecting
(1.20) plant growth is usually *least* variable from day to day under field conditions?

A. Temperature. B. Light.
C. Carbon dioxide concentration.
D. Relative humidity. E. Rainfall.

130. Which of the following might be regarded as an ex-
(1.20) ample of biological control of parasitic organisms?

A. Man's spraying of his apple trees to kill the larvae of the coddling moth.

B. Man's burning of crop residues in the field to kill the Hessian fly pupae.
C. Man's use of vermifuges to expel worms from the bodies of his livestock.
D. Man's release of the lydella fly into corn fields where it parasitizes and destroys the corn borer.
E. None of the above.

131. (1.20) Select the best response from those listed below with respect to those adaptations which may have evolved in response to the force of gravity.

A. Some of the movements of one-celled animals may be responses to tiny inclusions falling through their protoplasm.
B. The functioning of man's semicircular canals.
C. The singular structure of the bones of birds.
D. The curvature of man's spinal column.
E. All of the above.

132. (1.20) Why does an individual get sunburned more readily on a summer day on a mountain at 10,000 feet elevation than he does on a summer day at sea level?

A. An individual is closer to the sun on the top of the mountain.
B. The percent of oxygen in the atmosphere is lower at 10,000 feet than at sea level.
C. The temperature is higher at 10,000 feet than at sea level.
D. The atmospheric screen is thinner at 10,000 feet elevation.
E. There is no logical explanation of this phenomenon.

For items 133 - 137 associate each item with the appropriate factor of the physical environment listed in the key:

KEY

A. Pressure factor. **B.** Chemical factor.
C. Force of gravity. **D.** Light factor.
E. Heat factor.

133. (1.20) The velocity of chemical reactions increases two or three times with every 10°C. rise in temperature.

134. (1.20) Some deep sea fishes "explode" when brought to the surface.

135. (1.20) Magnesium is an essential element in the synthesis of the chlorophyll molecule.

136. (1.20) Red corpuscles of a frog when placed in a mammalian physiological salt solution will lose water and shrink.

137. (1.20) Coagulation of protoplasmic proteins can cause death.

138. (1.20) It is *inaccurate* to state that in any habitat

A. radically different kinds of organisms may be finding natural homes.
B. one will find representatives of all species of the organisms that can live in such a habitat.
C. one will find all the organisms organized as though in communities with interrelationships extending between species.
D. the boundaries will be marked by definite barriers preventing extension of the habitat.
E. all of the above four statements are untenable.

139. (1.20) A food chain may best be illustrated by which one of the following statements?

A. The earth would be devoid of plant life if there were no animal life.
B. An animal feeds upon another animal, as in parasitism.
C. Many organisms support a few which in turn support still fewer.
D. A few organisms support many which in turn support still more.
E. A few organisms support others usually in about the same numbers.

140. (1.20) Specialized adaptations fitting birds to their environment include all of these *except*

A. an enlarged brain but without marked increase in intelligence over their close relatives on the evolutionary scale.
B. a four-chambered heart.
C. marked improvement in the sense of sight.
D. the ability of the blood temperature to fluctuate from practically arctic to tropical temperatures.
E. marked increase in the size of the sternum allowing for attachment of larger wing muscles.

141. (1.20) Which of the following animals differs most from the four others in its food-gathering methods?

A. Clam. **B.** Oyster. **C.** Pearly nautilus.
D. Sponge. **E.** Tunicate.

142. (1.20) The number of calories involved in the change from water into steam is

A. greater than **B.** less than
C. same as that involved in the change from water into ice.

143. (1.20) The variation of temperature in water is

A. greater than **B.** less than
C. same as the variation of temperature in air.

144. (1.20) In the spring just after the ice has melted, the temperature of the very deep water is

A. greater than **B.** less than
C. same as the temperature of the shallow water.

145. (1.20) Heat loss per unit of body weight by a rat is

A. greater than **B.** less than
C. same as heat loss per unit of body weight by a mouse.

146. (1.20) The number of marine animals with floating larval stages is

A. greater than **B.** less than
C. same as the number of fresh-water animals with floating larval stages.

147. (1.20) The tendency toward gregariousness in animals near the base of the pyramid of numbers is

A. greater than **B.** less than
C. same as the tendency toward gregariousness in animals near the top of the pyramid of numbers.

148. (1.20) In the autumn before ice begins to form over a lake, the free oxygen concentration in deep water is

A. greater than **B.** less than
C. same as the free oxygen concentration in the shallow water.

149. (1.20) Late in the summer the number of fish in the epilimnion is

A. greater than **B.** less than
C. same as the number of fish in the hypolimnion.

150. (1.20) The temperature above the thermocline is

A. greater than **B.** less than
C. same as the temperature below the thermocline.

151. (1.20) Some cold-blooded animals which live in air may become active at very low temperatures because they gain heat by

A. conduction. **B.** evaporation.
C. increased metabolism.
D. transformation of light into heat.

152. (1.20) The free oxygen concentration in water is

A. greater than **B.** less than
C. same as the free oxygen concentration in air.

153. (1.20) The number of animals which are indirectly dependent on plants for food is

A. greater than **B.** less than
C. same as the number of animals directly dependent on plants for food.

154. (1.20) The abundance of flora and fauna in soft water lakes is

A. greater than **B.** less than
C. same as the abundance of flora and fauna in hard water lakes.

Items 155 - 158. As far as water balance is concerned an animal tends to

A. lose water. **B.** gain water.
C. neither lose nor gain water.

Which of the above conditions obtain in

155. (1.20) aerial animals.
156. (1.20) freshwater animals.
157. (1.20) marine animals generally.
158. (1.20) marine bony fish.

159. (1.20) The oxygen concentration in the hypolimnion is

A. greater than **B.** less than
C. same as the oxygen concentration in the epilimnion.

160. (1.20) The number of species of amphibia in freshwater is

A. greater than **B.** less than
C. same as the number of species of amphibia in the sea.

161. (1.20) The number of radially symmetrical animals which live in water is

A. greater than **B.** less than
C. same as the number of radially symmetrical animals which live on land.

162. (1.20) The numbers and size of reptiles in the temperate zones are

A. greater than **B.** less than
C. same as the numbers and size of reptiles in the tropics.

163. (1.20) From the standpoint of our conception of evolutionary complexity, which one of the following plants occupies the same position in relation to the other four as mankind occupies in relation to all the other species of animals, living and extinct?

A. Dandelion. **B.** Pine. **C.** Modern fern.
D. Moss. **E.** Seed fern.

164. (1.20) Which of the following organisms is most numerous in the open ocean?

A. Blue-green algae. **B.** Fungi.
C. Brown algae. **D.** Diatoms. **E.** Bryophytes.

Items 165 - 172. Certain special relationships between different organisms are designated as follows:

A. Commensalism. **B.** Parasitism. **C.** Symbiosis.

Which of these are represented by these associations?

165. (1.20) Ants and plant lice.
166. (1.20) Body louse of man.

167. (1.20) Harmless ameba in human intestine.

168. (1.20) Hermit crab and sea anemone.

169. (1.20) Intestinal protozoa of termites.

170. (1.20) Mites on ants.

171. (1.20) One-celled green plants in hydra.

172. (1.20) Suckerfish and shark.

173. (1.20) Which one of the following is *not* an adaptive value of seeds?

A. They can withstand very dry conditions for a long time.
B. Much nourishment is provided for the embryo.
C. They have special structures which promote wide distribution.
D. They secure improved transmission of hereditary characters.
E. They can withstand freezing temperatures.

For items 174 - 184 select the principle which best applies, then mark the corresponding answer space.

PRINCIPLES

A. Water is a basic medium for all life processes.
B. Food is the only form in which matter and energy are utilizable by living organisms.
C. Photosynthesis is the link between non-living energy resources and living organisms.
D. Diffusion is the basic mechanism of transport.
E. Cellular respiration is a process of utilizing energy in food.

STATEMENTS

174. (1.30) One gram of starch contains 4.2 calories of potential energy.

175. (1.30) Motile sperms characterize organisms which reproduce sexually.

176. (1.30) The atmosphere is the ultimate source of the carbon in the body of living organisms.

177. (1.30) Oxygen–carbon dioxide exchange in the alveoli is effected through thin membranes.

178. (1.30) $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$ + Energy.

179. (1.30) $6CO_2 + 6H_2O$ + Energy $\rightarrow C_6H_{12}O_6 + 6O_2$.

180. (1.30) Desiccated fruits, vegetables, and fish are not likely to deteriorate as readily as fresh ones.

181. (1.30) The developing human embryo is supplied nourishment and oxygen through the placenta.

182. (1.30) Animal protein is a highly concentrated and complex form of nutrient compound.

183. (1.30) Glycogen is released into the blood stream when adrenalin provides the stimulus.

184. An ameba obtains oxygen through its body wall directly from its surroundings.

For items 185 - 191 select the principle which best applies, then mark the corresponding space.

PRINCIPLES

- **A.** Life can be maintained only by the constant intake and utilization of matter and energy and their organization in a dynamic equilibrium.
- **B.** There is a coordination of food intake, oxygen intake, energy release and waste disposal in living organisms.
- **C.** There is an adjustment of the entire organism with the environment from which the organism gets food and oxygen and to which it returns waste products.
- **D.** Functional disease is a breakdown of a part of the complex organization which characterizes the living organism.
- **E.** Death and decomposition constitute the eventual and inevitable breakdown of the dynamic equilibrium characteristic of the living.

STATEMENTS

185. (1.30) Certain thermophilic bacteria develop best at temperatures considerably above 100°F.

186. (1.30) When there is a predisposing factor, hardening of the arteries often develops in middle or old age.

187. (1.30) Digestion of food is dependent upon enzyme secretion at the proper time.

188. (1.30) While the simplest organisms are characterized by potential immortality, in higher forms unending life proved to be disadvantageous to the species.

189. (1.30) Poultry raisers get increased egg production from their flocks by use of artificial lighting to extend the light period of the photoperiodic cycle. The extended light period seems to stimulate increased activity of the ovaries.

190. (1.30) A spasm of a heart blood-vessel may follow indulgence in severe muscular exercise by elderly people.

191. (1.30) Secretion of an insufficient amount of insulin by the islets of the pancreas results in deranged carbohydrate metabolism.

For items 192 - 199 select the principle which best applies, then mark the corresponding answer space.

PRINCIPLES

- **A.** Reproduction is a means of continuing life by the separation of a part of one individual to produce another.
- **B.** Heredity is a stabilizing factor which tends to make the offspring resemble the parent.
- **C.** Variation is the change factor which tends to make the offspring differ from the parent in certain respects and thus produce new types of individuals.
- **D.** Evolution is the consequence of heredity, variation, and selection through the history of life on the earth.
- **E.** Classification is a cataloging, on the basis of relationship, of the present-day forms that are the result of evolution.

STATEMENTS

192. (1.30) Gradual development, through countless centuries, of thermostatic control of body temperature has enabled some organisms, notably man, to adapt themselves to habitats ranging from the steaming tropics to the perpetually frigid polar areas.

193. (1.30) A more efficient aeration system distinguishes the higher vertebrates from the lower vertebrates.

194. (1.30) An albino child may be born to parents who are not albinos.

195. (1.30) In birds, development has already started before the egg is laid; in some snakes the young leave the egg shell before passing from the mother.

196. (1.30) Identical twins possess very nearly the same talents and aptitudes.

197. (1.30) The group to which insects belong contains most of the known animals on the earth.

198. (1.30) A successful democracy can spring only from good human stock.

Items 199 - 203. Mutualism between two species of living organisms may be one of three kinds of relationships:

1. Symbiosis. 2. Commensalism. 3. Parasitism.

Before each of the following descriptions of mutualism write the number of the type of relationship it represents.

199. (1.30) _____Hooked glochidia (young clams) clamp to the gill filaments of a fish. In a few hours each glochidium becomes surrounded by a capsule formed by migration of cells of the fish's epithelium. The glochidia feed and grow by absorbing nutrients from the fish's body fluids.

200. (1.30) _____One species of paramecium contains spherical green algae in its endoplasm. The carbon dioxide produced by the protozoan in respiration serves the algae with their chlorophyll to synthesize organic materials and produce oxygen, both of which are used by the paramecium.

201. (1.30) ______The Remora fish possesses on the dorsal surface of its head a flat oval sucker disc, by which the fish attaches itself to the ventral surface of a shark. Since the shark is a better swimmer this increases the Remora fish's forage range.

202. (1.30) ______Certain termites eat wood but have no digestive enzymes capable of digesting cellulose. In the termite's intestine, however, lives a species of flagellate protozoans which digest cellulose with ease. Deprived of their flagellates the termites starve to death. Moreover, the flagellates cannot survive outside the body of the termites.

203. (1.30) ______Mistletoe, a flowering plant, grows in dense clumps on the branches of oaks and other trees. Wedge-shaped masses of mistletoe tissue penetrate the branches of the tree along the medullary rays whence nutrient fluids are obtained by the mistletoe.

For items 204 - 218 select the principle which best applies, then mark the corresponding answer space.

PRINCIPLES

- **A.** Overproduction in every species of living organism results in competition for available food.
- **B.** Cooperation is a determining factor for survival.
- **C.** Conservation of matter and energy resources is necessitated by their occurrence in limited supply.
- **D.** Parasitism is a specialization of the organism-environment relationship.
- **E.** Natural selection acts ultimately to determine which individuals and, hence, which species will survive.

STATEMENTS

204. (1.30) Many farmers burn the cornstalks after harvest to tidy up their fields prior to the next plowing. Other farmers plow the stalks under.

205. (1.30) Within the body of the green hydra live many one-celled green algae which utilize in food manufacture the hydra's discharged carbon dioxide, and in exchange provide the hydra with oxygen.

206. (1.30) Abandoned despoilation banks, which remain following coal strip-mining operations, will require hundreds of years to become agriculturally productive again.

207. (1.30) "Big fleas have little fleas
Upon their backs to bite 'em;
Little fleas have smaller fleas,
And so *ad infinitum.*"

208. (1.30) A female eel lays from 5,000,000 to 20,000,000 eggs at great depth in the sea.

209. (1.30) A little more fleetness, a bit more strength, a slightly greater protective coloration, a more responsive nervous system, or any one of thousands of differences may be the decisive factor which means life or death to the creature in danger.

210. (1.30) Animals and plants are not preyed upon alone by successively larger forms which overpower and eat them; they are also preyed upon by successively smaller forms which destroy only small, more or less replaceable portions, or even more subtly exploit the energies of the host by subsisting on the food which the host has collected with great expenditure of time and energy.

211. (1.30) "Cut out and get out," was the procedure employed by the Michigan timber scavengers in the 1880-1910 period.

212. (1.30) Certain luminescent bacteria, living in the body of a marine fish, obtain nutrition from their bearer and, in turn, provide the fish with a lantern, a warning signal, or a recognition device.

213. (1.30) The Norwegian lemming (a small rat-like rodent) fluctuates in number between minima and maxima in a 4-year rhythm, the maxima being followed by a migration to the sea resulting in mass destruction of these creatures.

214. (1.30) Certain termites chew and swallow hard dry wood but lack enzymes capable of digesting it; the innumerable protozoa living in the termites' intestines eat and digest the woody tissue for themselves and incidentally for the termites.

215. (1.30) The existence of a dog's fleas is usually an elaborate compromise between extracting sufficient nourishment to sustain their own lives and not impairing too much the vitality of the dog who is providing them with a home and a free ride.

216. (1.30) Insects of the Kerguelen Islands (where strong gales, in which small flying forms are likely to be blown to sea and perish, are of constant occurrence) show remarkable modification. It is a significant fact that the insects of these islands, although closely related to winged mainland forms, are flightless and in some cases even wingless.

217. (1.30) The gray rat, when introduced into America, crowded out the black rat.

218. (1.30) The potential progeny of one pair of house flies is two million millions in 12 weeks.

For items 219 - 223 select from the five principles below the most closely related principle and mark the corresponding answer space.

PRINCIPLES

- **A.** Cooperation is a determining factor for survival.
- **B.** Offspring always vary at least slightly from their parents.
- **C.** The closer the resemblance between two organisms the more recent have been the common ancestors.
- **D.** Natural selection acts ultimately to determine which individuals and, hence, which species will survive.
- **E.** Living organisms tend to reproduce in greater numbers than can survive.

STATEMENTS

219. (1.30) Aboriginal races have time after time been largely or even wholly destroyed by contact with the white man, through war to a certain extent, but even more effectively through the introduction of his diseases and his vices.

220. (1.30) The female codfish lays approximately 9,000,000 eggs in one season.

221. (1.30) The gray rat when introduced into America crowded out the existing black rat.

222. A little more fleetness, a bit more strength, a slightly greater protective coloration, a more responsive nervous system, or any one of thousands of differences may be the decisive factor which means life or death to the creature in danger.

223. (1.30) Insects of the Kerguelen Islands, where strong gales in which small flying forms are likely to be blown to sea and perish are of constant occurrence, show remarkable modification. It is a significant fact that the insects of these islands, although closely related to winged mainland forms, are flightless and in some cases even wingless.

For each of the items 224 - 229, select from the following list the *one* principle best illustrated and blacken the appropriate space on your answer sheet.

PRINCIPLES

A. Ecological or biotic succession.
B. Food chain. **C.** Mutualism (symbiosis).
D. Parasitism. **E.** None of these.

224. (1.30) Eggs of an animal called the fluke develop into larvae known as miracidia, which bore into the bodies of certain snails. They encyst here, and eventually produce another type of larva known as cercaria. The cercaria leave the body of the snail, reach land, and encyst upon grass or leaves. Sheep swallow these cysts, they are dissolved away by intestinal juices, and the liberated flukes find their way to the bile ducts of sheep causing liver damage.

225. (1.30) Legumes will not grow on sterile, impoverished soil. Certain bacteria possessed of only a slight ability to fix atmospheric nitrogen when alone, have this ability enormously increased by association with legumes, utilizing some of the carbohydrate manufactured by the plants. The legumes, on the other hand, grow far better on soil innoculated with the nitrogen-fixing bacteria.

226. (1.30) In the Yser district in Belgium during World War I, the sea was allowed to inundate the country in order to prevent the advance of the Germany army. The sea water killed off nearly every living plant in the region. When the country was drained again, the bare sea bottom was invaded by salt-marsh plants, but these gave way gradually to almost normal vegetation until in many places the only traces of advance and retreat of the sea were the skeletons of various marine invertebrates scattered over the countryside.

227. (1.30) A certain paramecium regularly harbors within its protoplasm a green alga, Chlorella. This animal lives longer without feeding when placed in the light than when placed in the dark. Apparently there is a physiological interchange of the products of metabolism; the animal receives food and oxygen; the plant receives carbon dioxide, water, and nitrogenous substances.

228. (1.30) In moist areas the burrowing of earthworms loosens the soil and encourages the decay of organic matter. In dry soils where earthworms cannot live, the turning over of the soil is performed largely by ants.

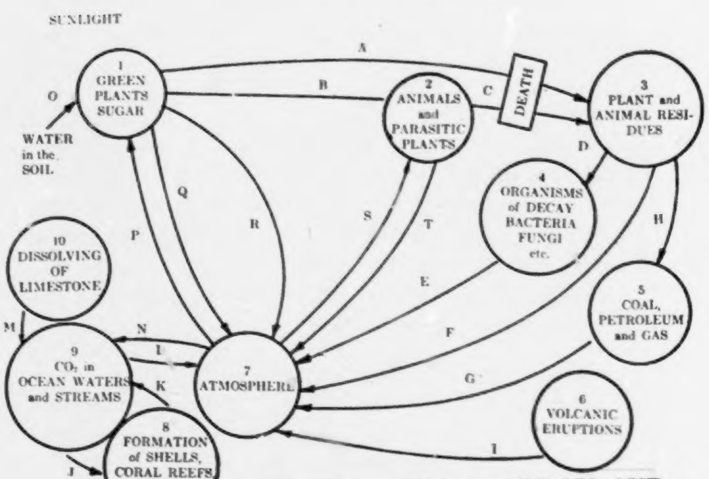
229. (1.30) In a forest the trees produce enough energy-bearing substances to support not only themselves, but the vast number of aphids (plant lice), the beetles which feed on the aphids, and the birds which feed on the beetles.

Items 230 - 241 refer to Figure I. THE CARBON AND OXYGEN CYCLES (next column).

230. (2.20) The equation $6CO_2 + 6H_2O + \text{Energy} \rightarrow C_6H_{12}O_6 + 6O_2$ is associated with

A. Circle 1. **B.** Circle 2. **C.** Circle 3.
D. Circle 4. **E.** Circle 5.

CHEMICAL CYCLES IN NATURE


SUNLIGHT
1 GREEN PLANTS SUGAR
2 ANIMALS and PARASITIC PLANTS
3 PLANT and ANIMAL RESIDUES
4 ORGANISMS of DECAY BACTERIA FUNGI etc.
5 COAL, PETROLEUM and GAS
6 VOLCANIC ERUPTIONS
7 ATMOSPHERE
8 FORMATION of SHELLS, CORAL REEFS, etc.
9 CO₂ in OCEAN WATERS and STREAMS
10 DISSOLVING OF LIMESTONE
WATER in the SOIL
DEATH
A
B
C
D
E
F
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T

FIGURE I. THE CARBON AND OXYGEN CYCLES

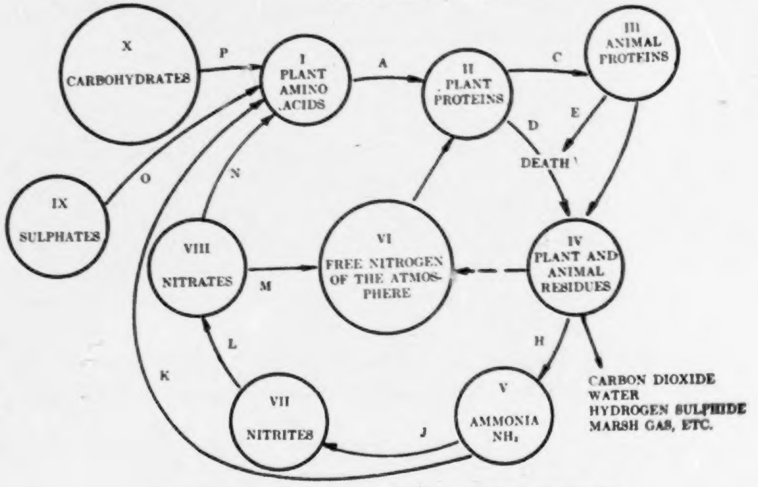

X CARBOHYDRATES
I PLANT AMINO ACIDS
II PLANT PROTEINS
III ANIMAL PROTEINS
IV PLANT AND ANIMAL RESIDUES
V AMMONIA NH₃
VI FREE NITROGEN OF THE ATMOSPHERE
VII NITRITES
VIII NITRATES
IX SULPHATES
DEATH
CARBON DIOXIDE
WATER
HYDROGEN SULPHIDE
MARSH GAS, ETC.
A
C
D
E
H
J
K
L
M
N
O
P

FIGURE II. THE NITROGEN CYCLE

231. (2.20) "Cellular respiration is a process of utilizing energy in food." This process is represented by

A. Circle 5 and line G. **B.** Circle 4 and line E.
C. Circle 6 and line I. **D.** Circle 7 and line P.
E. Circle 7 and line N.

232. (2.20) Food for all living things on the earth results from the activities represented

A. by line E. **B.** by line C. **C.** by line Q.
D. in circle 1. **E.** in circle 3.

233. (2.20) Lines E, F, G, and I represent the passage of

A. oxygen. **B.** nitrogen. **C.** carbon dioxide.
D. hydrogen. **E.** none of these.

234. (2.20) "Life can be maintained only by the constant intake and utilization of matter and energy and their organization in a dynamic equilibrium." This principle is best illustrated by

A. Circle 3 with all its entering and outgoing lines.
B. Circle 7 with all its entering and outgoing lines.
C. Circle 5 with all its entering and outgoing lines.
D. Circle 9 with all its entering and outgoing lines.
E. Circle 2 with all its entering and outgoing lines.

235. (2.20) A primary vitamin source is represented by line(s)

A. O and P. **B.** U. **C.** E. **D.** F.
E. Q, R, and T.

236. $C_6H_{12}O_6 + 6O_2 \rightarrow \text{Energy} + 6CO_2 + 6H_2O$ is
(2.20) represented as involved in all except which one of the following?

A. Line R. **B.** Line S. **C.** Line T.
D. Lines E and G. **E.** Line O.

237. "Food is the only form in which matter and energy is
(2.20) utilizable by living organisms." In the process of food production, the energy component is represented as coming in on lines

A. G and I. **B.** O and P. **C.** U.
D. E and F. **E.** R and T.

238. A very potent complex catalyst is involved in the activi-
(2.20) ties which are represented as occurring in

A. Circle 1. **B.** Circle 3. **C.** Circle 4.
D. Circle 6. **E.** Circle 10.

239. In the production of a tree, the heavier of the raw
(2.20) materials is derived from the source which is the point of origin of

A. line U. **B.** line P. **C.** line O.
D. line S. **E.** line B.

240. "There is a coordination of food intake, oxygen intake,
(2.20) energy release, and waste disposal in living organisms." This principle is represented in which one of the following circles?

A. Circle 2. **B.** Circle 5. **C.** Circle 6.
D. Circle 7. **E.** Circle 10.

241. Which one of the following circles represents the stage
(2.20) at which a partial breakdown of dynamic equilibrium has occurred?

A. Circle 1. **B.** Circle 2. **C.** Circle 3.
D. Circle 7. **E.** Circle 9.

Items 242 - 247 refer to Figure II, THE NITROGEN CYCLE, page 258.

242. A farmer has planted sweet clover (a legume) on the
(2.20) least productive plot of ground on his farm. The benefit which will accrue is due to a process represented by

A. line A. **B.** line B. **C.** line G.
D. line I. **E.** line M.

243. Putrefaction products are indicated
(2.20)

A. beyond line I. **B.** within Circle I.
C. within Circle II. **D.** within Circle III.
E. within Circle IX.

244. Nitrogen fixation is represented as occurring between
(2.20)

A. Circle IV and Circle VI (line G).
B. Circle VIII and Circle VI (line M).
C. Circle VIII and Circle I (line N).
D. Circle VI and Circle II (line B).
E. Circle VII and Circle VIII (line L).

245. Anaerobic bacterial action is represented by
(2.20)

A. line B. **B.** line C. **C.** line I.
D. line N. **E.** line O.

246. The most complex chemical product involved in the
(2.20) nitrogen cycle is represented in

A. Circle I. **B.** Circle II. **C.** Circle III.
D. Circle VI. **E.** Circle X.

247. The process of decay is represented by
(2.20)

A. lines I and H. **B.** lines J and K.
D. line C. **E.** line B.

Items 248 and 249 refer to both Figure I and Figure II.

248. The most abundant gas in the earth's atmosphere is
(2.20)

A. oxygen. **B.** carbon dioxide. **C.** nitrogen.
D. hydrogen. **E.** water vapor.

249. Under natural conditions, the atmospheric gas repre-
(2.20) sented in these cycles which imposes a strict limit on potential world food production by its rare occurrence in the atmosphere is

A. nitrogen. **B.** oxygen. **C.** carbon dioxide.
D. hydrogen. **E.** ammonia.

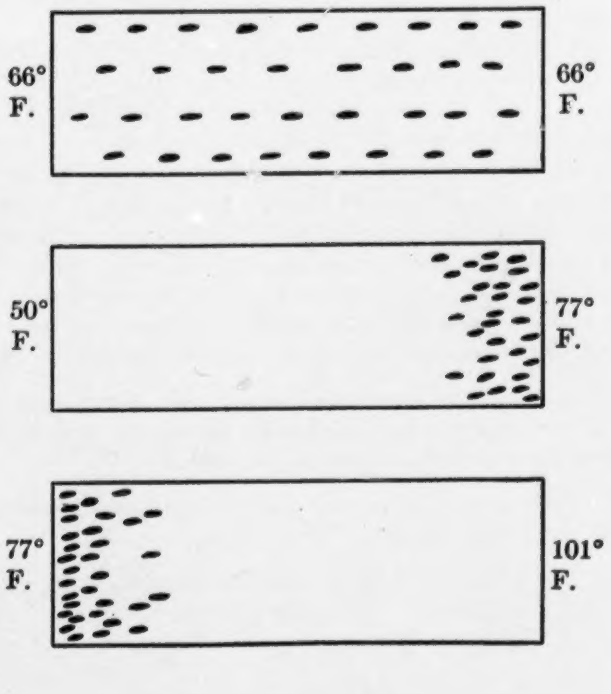
250. The destruction of all bacteria would bring life on the
(2.20) earth to an end, because

A. they are the hardest organisms to kill.
B. the organisms that feed on bacteria would starve, initiating a chain of starvation reaching to man.
C. the available nutrients would presently be immobilized in undecayed vegetation and animal bodies.
D. evolution begins with bacteria.

251. A termite is unable to digest the small particles of wood
(2.20) which it chews off and swallows. Protected and housed in the digestive tract of the termite are amoebae that digest the wood and supply the termite with absorbable nutriment. Neither animal could live without the other. One can conclude from these facts that

A. this is a parasitic relationship.
B. the amoebae could manage to live independently.
C. the termite lives on waste products of the amoeba.
D. an amoeba and termite have the same enzymes.
E. wood can be digested by the termites.

252. Below are represented three microscope slides com-
(2.20) pletely covered with films of water containing paramecia. The responses of the paramecia to different temperatures are indicated.



On the basis of the above evidence which of the following appears to be the optimum temperature range for paramecia?

A. 60°F. to 70°F. **B.** 70°F. to 80°F.
C. 77°F. to 101°F. **D.** 50°F. to 77°F.
E. None of these.

You are lost in the sand dunes of Indiana, but in an area not characterized by a "blow out," changes made by man, or other atypical aspects. After each item number on the answer sheet, for items 253 - 256, blacken space

A. if you are in the pine association.
B. if you are in the foredune association.
C. if you are getting closer to Lake Michigan.
D. if you are getting farther from Lake Michigan.
E. if you are in the climax association.

253. (2.20) You observe some snails and red wood frogs; beech and maple trees predominate.

254. (2.20) As you continue, the maple trees become more abundant, with very few shrubs and plants on the forest floor and there is a thick covering of dead leaves.

255. (2.20) After making a few turns you pass through white, red, and black oaks and begin to encounter cottonwoods.

256. (2.20) You finally find yourself in low dunes with sand grasses, sand cherries, and willows in abundance.

Items 257 - 271. Read the following selection carefully.

During the first year of a three-year study of an oak log, an ecologist found some jumping spiders and beetles on the surface and earthworms and bacteria under the log.

The next year, he found more spiders and beetles on the bark; between the bark and wood were bark beetle larvae and wood roaches; between the trunk and soil were earthworms, vegetarian millipedes (thousand leggers) and a few insect larvae. Bacteria, a few molds, and one mushroom plant were also present.

The third year he found that some organisms of the previous years had disappeared and had been replaced by many others. On the bark one jumping spider held a paralyzed fly between its poison jaws. Under the loose bark were three species of wood-eating bark beetle larvae, roaches, and a few small land snails, one of which served as food for a firefly larva. In the same place were the black, gray, and white thread-like bodies of mold and mushroom plants. A few termites had tunneled into the wood. The cellulose of the wood eaten by the termites was digested, not by the termites, but a protozoan inhabiting their intestines. Between the trunk and soil he found earthworms, and a centipede (hundred legger) devouring one of many insect larvae. One of several predaceous beetles fed on a firefly larva. A blood-sucking mite was attached to one of the beetles. Fly larvae (maggots) were feeding on the body of a dead earthworm. From under the log slithered a garter snake, interrupted while feeding on a beetle. Oak seedlings germinated from acorns hidden under the log by a squirrel, and caterpillar-infested basswood seedlings grew close to the trunk.

After each exercise number on the answer sheet, blacken the *one* lettered space which designates the correct answer. Refer back to the selection as often as you wish.

257. (2.20) The change in animal and plant population associated with this log is

A. a biome. **B.** a biotic succession.
C. symbiosis. **D.** saprophytism.
E. commensalism.

258. (2.20) Carnivores are represented by

A. squirrels and millipedes. **B.** termites.
C. spiders, centipedes, and snakes.
D. earthworms and snails.
E. bark beetle larvae and fly larvae.

259. (2.20) Herbivores are represented by

A. squirrels and caterpillars. **B.** predaceous beetles.
C. spiders and centipedes. **D.** garter snakes.
E. mold and mushroom plants.

260. (2.20) The relationship between the termites and their one-celled "guests" is an example of

A. saprophytism. **B.** parasitism. **C.** symbiosis.
D. commensalism. **E.** predatism.

261. (2.20) In the relationship between termites and the one-celled "guests"

A. neither benefits. **B.** the "guests" only benefit.
C. both benefit. **D.** both are injured.
E. the termites only benefit.

262. (2.20) The first animals to live on the inside of the log are

A. carnivores. **B.** herbivores. **C.** scavengers.
D. insectivores. **E.** symbionts.

263. (2.20) The only organisms not directly dependent on external sources of organic materials for food are

A. spiders, centipedes, and snakes. **B.** termites.
C. oak and basswood seedlings.
D. mold and mushroom plants. **E.** bacteria.

264. (2.20) Parasitism is best illustrated by the relationship between

A. squirrel and acorn. **B.** snake and beetle.
C. mushroom and log. **D.** mite and beetle.
E. termite and its one-celled "guest."

265. (2.20) The non-green plants are important because they

A. tunnel through the wood.
B. cause disease of the animals in this community.
C. liquefy the log.
D. make available chemicals for future generations of plants and animals.
E. serve as food for the firefly larvae.

266. (2.20) The new organisms of the third year had not appeared previously because

A. living conditions were unfavorable.
B. snakes and squirrels had not carried them to the log.
C. there was no water.
D. they were not in the region.
E. cold had killed them off previously.

267. (2.20) The fly larvae feeding on the body of the dead earthworm are

A. saprophytes. **B.** parasites. **C.** symbionts.
D. herbivores. **E.** scavengers.

268. (2.20) The relationship between the wood, snails, firefly larvae, predaceous beetle, and snake is a

A. biome. **B.** biotic succession. **C.** food chain.
D. case of symbiosis. **E.** case of saprophytism.

269. If in the preceding relationship all firefly larvae or
(2.20) beetles die

A. the snails would tend to decrease in number.
B. the snakes would tend to increase in number.
C. no change would occur.
D. the snails would tend to increase in number.
E. all remaining animals would tend to increase in number.

270. When after a number of years this community remains
(2.20) unchanged, it is in the

A. pioneer condition. B. hydrophytic condition.
C. mesophytic condition. D. xerophytic condition.
E. climax condition.

271. Non-green plants, like those in the log, may be a
(2.20) nuisance to man because they

A. appear unappetizing. B. absorb water.
C. decompose this log.
D. may spoil foods and lumber. E. kill livestock.

272. If we encounter a "food chain" in which species B feeds
(2.20) upon A, C upon B, D upon C, and E upon D, we would be most apt to find reproduction without fertilization in species

A. A. B. B. C. C. D. D. E. E.

For items 273 - 293 blacken space

A. if the increase of the first item normally tends to produce an increase in the second.
B. if the increase of the first item normally tends to produce a decrease in the second.
C. if there is no appreciable effect of the first item on the second.

273. The lamprey population in the Great Lakes.
(2.20) The number of lake trout and whitefish.

274. The number of algae in a lake.
(2.20) The number of small crustaceans.

275. The amount of silt in streams.
(2.20) The number of oysters and clams.

276. The amount of oxygen in the air.
(2.20) The number of plants in a forest.

277. Prevalence of parasites and epidemics in mountain lions.
(2.20) The number of deer.

278. The grass land on a young dune.
(2.20) The number of animals found in a drift line.

279. Replacement of up- and down-plowing by contour-
(2.20) plowing.
The amount of erosion.

280. Acreage planted to legumes.
(2.20) The amount of nitrogen in the soil.

281. The number of field mice on a farm.
(2.20) The number of owls.

282. The amount of ocean plankton.
(2.20) The amount of nitrogen in the soil.

283. The amount of acreage planted to corn.
(2.20) The amount of nitrogen in the soil.

284. The amount of shade in a climax forest.
(2.20) The number of herbaceous "forest floor" plants.

285. The number of field mice in a field.
(2.20) The number of bumblebees.

286. The mineral content of soil.
(2.20) The quantity of minerals in plants grown on the soil.

287. The number of lichens growing on a rock.
(2.20) The amount of soil.

288. Temperature of the environment of a mammal.
(2.20) Body temperature of the mammal.

289. The amount of CO_2 taken in by plants.
(2.20) The amount of food available to animals.

290. The number of plants growing on fallow land.
(2.20) The amount of erosion.

291. The amount of erosion.
(2.20) The height of the water table in the ground.

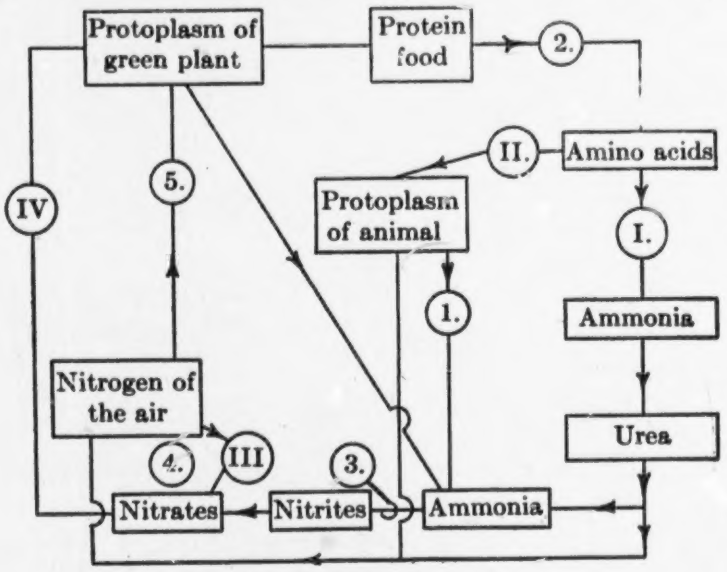
292. The number of nitrogen-fixing bacteria in the soil.
(2.20) The amount of decay in soil.

293. The number of cattle grazing on a given area of range.
(2.20) The amount of erosion.

294. Which of the following best describes the relationship
(2.20) of man to the other living organisms on the earth?

A. Every living organism was designed to benefit man in some way.
B. Man was intended from the outset to be the keeper and custodian of the living things on the earth.
C. As man uses other creatures for his survival, so others use him to further theirs.
D. If man were to disappear from the earth, life among the remaining organisms would be seriously disrupted.
E. Man and the other organisms populating the earth are independent of each other.

Items 295 - 301 refer to the diagrammatic representation of the Nitrogen Cycle shown below.



NITROGEN CYCLE

For items 295 - 299 indicate along which of the Arabic numbered arrows each of the following would be significantly involved.

295. Enzymes.
(2.20)

296. Denitrifying bacteria.
(2.20)

297. Nitrifying bacteria.
(2.20)

298. Putrefactive bacteria.
(2.20)

299. Nitrogen-fixing bacteria.
(2.20)

For items 300 - 301 indicate along which of the Roman numbered arrows each of the following processes would be most significantly involved. If not involved at all, mark space 5.

300. Growth.
(2.20)

301. Absorption by plant roots.
(2.20)

For items 302 - 306 use the following key:

KEY

- **A.** The atmosphere is the source of oxygen and the place of disposal of carbon dioxide for practically all living things.
- **B.** Evaporation is a heat-absorbing process and the rate of evaporation is partially controlled by the concentration of the evaporating vapor above the evaporating liquid.
- **C.** Solar energy can effect a loosening of chemical bonds between some atoms and the strengthening of bonds between other atoms.
- **D.** The atmosphere contains many inert materials that combine with other elements with difficulty.

302. If a board is left lying on the lawn the grass will lose its green color.
(2.20)

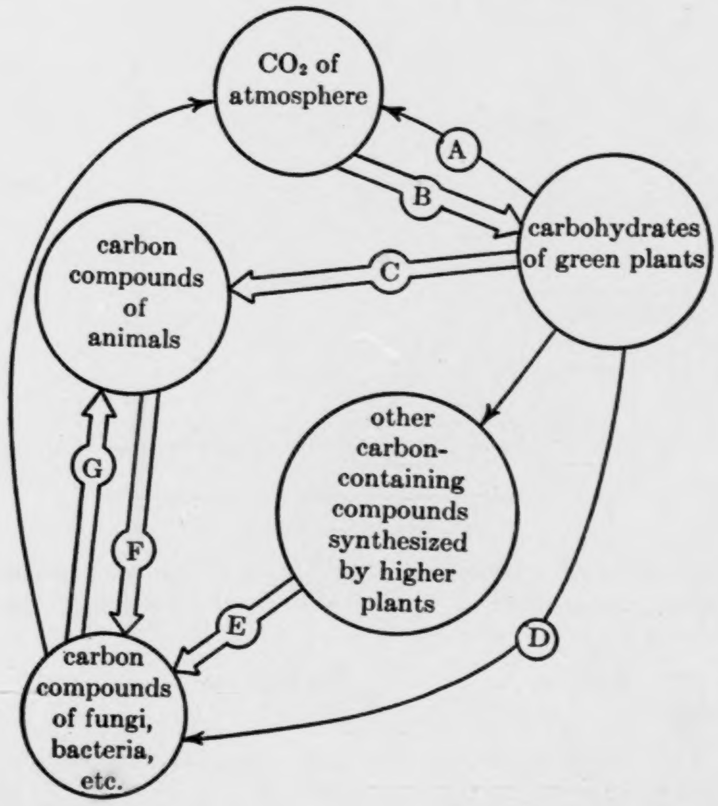
303. Children of southern sharecroppers often become afflicted with intestinal parasites.
(2.20)

304. Were it not for certain types of bacteria, commercial fertilizers would be in even greater demand.
(2.20)

305. Eggs, although fertile, will not hatch if allowed to collect a thin film of oil before incubation.
(2.20)

306. Conservation officers know that if too deep a layer of snow is allowed to collect on the ice over lakes the fish in the lakes will die from lack of oxygen even though there are holes through the ice.
(2.20)

Items 307 - 313. Study the following diagram and select answers to these items from the key list following the diagram.


CO₂ of atmosphere
A
B
carbohydrates of green plants
carbon compounds of animals
C
other carbon-containing compounds synthesized by higher plants
G
F
E
D
carbon compounds of fungi, bacteria, etc.

KEY

- **A.** Decay
- **B.** Photosynthesis
- **C.** Respiration
- **D.** Feeding
- **E.** Energy

307. What is represented by the arrow labelled *A*?
(2.20)

308. What is represented by the arrow labelled *B*?
(2.20)

309. What is represented by the arrow labelled *C*?
(2.20)

310. What is represented by the arrow labelled *D*?
(2.20)

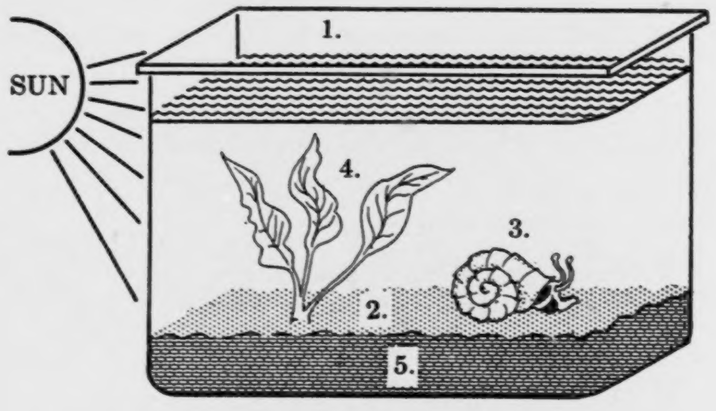
311. What is represented by the arrow labelled *E*?
(2.20)

312. What is represented by the arrow labelled *F*?
(2.20)

313. What is represented by the arrow labelled *G*?
(2.20)

Items 314 - 316 deleted.

Items 317 - 320 refer to the following diagram of a *sealed* aquarium.



SEALED AQUARIUM.

In this sealed aquarium, figure 1 represents the enclosed air above the water, figure 2 the water, figure 3 the animal life in the water, figure 4 the plant life, and figure 5 the soil at the bottom.

317. If the proper number of plants and animals had been placed in this aquarium before being sealed, and proper environmental conditions maintained, it would be possible for life to remain in the aquarium
(3.00)

- **A.** as long as the original oxygen in the air was sufficient to sustain life.
- **B.** as long as the oxygen originally in the air or dissolved in the water was sufficient to sustain life.
- **C.** at the most only a few months.
- **D.** as long as the sun shone on the aquarium at frequent intervals.
- **E.** as long as the original nitrogen in the soil was sufficient to maintain life.

318. Energy entering the cycle existing in this aquarium
(3.00) would first have to contact

A. any one figure. **B.** any two figures.
C. figure number 3. **D.** figure number 4.
E. no one figure.

319. The oxygen supply is at least partially replenished in
(3.00) figure________?

320. Carbon dioxide is replenished in
(3.00)

A. 1 and 2. **B.** 2 and 3. **C.** 3 and 4.
D. 4 and 5. **E.** no two figures.

Items 321 - 335. After the number on the answer sheet corresponding to that of each of the following paired items, blacken space

- **A.** if the item in Column I is of greater magnitude than the item in Column II.
- **B.** if the item in Column I is of less magnitude than the item in Column II.
- **C.** if the item in Column I is of essentially the same magnitude as the item in Column II.

	Column I	*Column II*
321. (3.00)	The number of lemmings in a given area of the tundra.	.... The number of foxes in a given area of the tundra.
322. (3.00)	The reproductive capacity of the herbivores of a given area.	.... The reproductive capacity of carnivores of a given area.
323. (3.00)	The amount of organic material in the sub soil.	.... The amount of organic material in top soil.
324. (3.00)	The number of organisms in the palagic (open surface) area of the oceans.	.... The number of organisms in the abyssal (deep) area of the oceans.
325. (3.00)	The average annual temperature of the coniferous forest biome.	.... The average annual temperature of the deciduous forest biome.
326. (3.00)	The effect of the complete removal of herbivores upon the carnivore population of a given area.	.... The effect of the complete removal of food plants upon the herbivore population of a given area.
327. (3.00)	The role of ants in the grassland biome.	.... The role of earthworms in the deciduous forest biome.
328. (3.00)	The contributions of animals to plant life.	.... The contributions of plants to animal life.
329. (3.00)	Contour cultivation as a means of soil erosion control on slopes.	.... Crop rotation as a means of soil erosion control on slopes.
330. (3.00)	The benefits of a symbiotic relationship.	.... The harmful effects of symbiotic relationship.
331. (3.00)	The ability of some bacteria to use gaseous nitrogen.	.... The ability of most green plants to use gaseous nitrogen.
332. (3.00)	The amount of grasses growing on the beaches of the Indiana dunes area.	.... The amount of grasses growing on the fore dunes of the Indiana dunes area.
333. (3.00)	The amount of moisture in a mesophytic area.	.... The amount of moisture in a xerophytic area.
334. (3.00)	The effect of pollution upon the game fish population.	.... The effect of overfishing upon the game fish population.
335. (3.00)	The stability of the cottonwood area in the Indiana dunes succession.	.... The stability of the beech-maple area in the Indiana dunes succession.
336. (3.00)	The amount of light available to pelagic organisms.	.... The amount of light available to abyssal organisms.

Items 337 - 346. After each item number on the answer sheet, blacken space

- **A.** if increase of the first item referred to promotes an increase of the second.
- **B.** if the increase of the first of the items referred to promotes a decrease of the second.
- **C.** if there is no appreciable effect of the first of the items on the second.

337. Exposure to sunlight or ultra violet rays.
(3.00) Increase in Vitamin B_1.

338. Increase of number of lemming.
(3.00) Number of caribou.

339. Increase of number of caribou.
(3.00) Number of eskimos.

340. Denuding of the forests.
(3.00) Floods.

341. Shooting coyotes and badgers.
(3.00) Grasses.

342. Draining swamps and shallow rivers.
(3.00) Ducks and geese.

343. Cattle grazing.
(3.00) Weeds in pasture land.

344. Forest fires.
(3.00) Jack pine, aspen, and ferns.

345. Earthworms.
(3.00) Ants.

346. Grazing, farming, and burning.
(3.00) Top soil.

347. If a farmer could eliminate all the insects from his land,
(3.00) he would lose most of his

A. vegetable crops. **B.** pine woods.
C. pasture grasses. **D.** livestock. **E.** soil bacteria.

348. Most of the large vertebrate herbivores are removed
(3.00) from an isolated, ecologically balanced pine forest community. Very few small vertebrate herbivores or small vertebrate carnivores are eaten by large carnivores. About midway in the period of re-establishment of ecological equilibrium,

A. the small herbivores will be tending to increase in number.

B. the larger carnivores will be tending to decrease in number.

C. the total amount of plant life will have remained constant.

D. the remaining large herbivores will have experienced a lower death rate from disease and starvation than before the disturbance.

349. Toads found in gardens should be
(3.00)

A. killed because they destroy the roots of vegetables.

B. killed because they reduce photosynthesis by eating the leaves off the plants.

C. killed because they spread infection—particularly warts—by leaving a virus on the plants.

D. protected because they help pollinate the flowers.

E. protected because they eat insects.

350. A plant physiologist directing the scientific aspects of a
(3.00) large vegetable producing and canning company in a midwestern state achieved a 23% increase in yield of beans by inoculating the seed. With what were the seeds probably inoculated?

A. Vitamins. **B.** Anti-fungus serum.
C. Nitrogen-fixing bacteria. **D.** Insect poison.
E. Leaf mosaic virus.

351. A biological principle states that the factor present in
(3.00) minimum concentration in the environment of an organism may limit the growth and distribution of that organism. Which of the following events would limit the process of photosynthesis by reducing the CO_2 content of the atmosphere over the earth's surface?

A. Volcanic eruptions. **B.** Combustion of wood.
C. Respiration of bacteria. **D.** Putrefaction.
E. None of these.

352. An article entitled "The Plants of Krakatoa" by Fritz W.
(3.00) Went tells of the complete sterilization of an island in 1883 by eruption where about 10 cubic miles of rock and pumice were blown into the air. Forty-seven years later there was a dense vegetation covering the island. Which of the following activities would be least likely to account for the profuse resettlement of organisms?

A. Artificial cultivation by man.

B. Natural distribution of seeds and spores by the wind.

C. Transport of seeds by birds.

D. Spontaneous generation.

E. Transport of seeds by ocean currents.

353. A potato stored in a warm, dark, moist cellar may pro-
(3.00) duce sprouts which are many times as long as a normal potato plant measured from root tip to stem tip. This is good evidence that

A. light is essential for plant growth.

B. light may increase the rate of plant growth.

C. light tends to inhibit cell elongation.

D. stored food escapes from a potato when placed in the soil.

E. a potato is an underground stem.

354. Which of the following is the most likely consequence
(3.00) to plants of potassium deficiency in agricultural soil?

A. Seeds are unlikely to germinate.

B. Leaves will not function to their full capacity.

C. The vascular bundles in the plant stem will fail to function.

D. Plants will be easily blown down by strong winds due to weak root systems.

E. Since potassium is not one of the constituents of either starch or glucose, no detrimental effect will be apparent.

355. Which one of the following gives evidence that animals
(3.00) living in groups, even though unorganized, have a better chance of survival than those living alone?

A. When geese migrate the flock follows the leader.

B. When a herd of deer is grazing the individuals alternate in maintaining a look-out for enemies.

C. In a bee-hive the queen takes over the reproductive duties in which the drone assists, while the sterile females are the workers charged with the responsibility of gathering food.

D. Some individuals in a colony of termites belong to the soldier caste which protects the colony against invaders.

E. A large group of fish can tolerate an amount of poison in the water that would kill a very few.

Items 356 - 367 are hypotheses concerning life *in the abyssal depths of the seas.*

The following are environmental factors concerning these depths:

A. There is an absence of light.

B. The water is still or in very slow motion.

C. The temperature is low but not below the freezing point.

D. Great pressures exist.

E. The environmental conditions are constant over wide areas.

F. A relatively large number of organisms live under these conditions.

For the items select from the following key the most appropriate response.

KEY

A. An hypothesis which is reasonable in the light of the above information.

B. An hypothesis which is *not* reasonable in the light of the above information.

C. An hypothesis which might be supported by the above information *but* which is *contrary* to an accepted biological principle.

356. Scavengers and carnivores make up the greater part of
(3.00) the animal life.

357. A greater percentage of the forms have light-producing
(3.00) organs than those forms living near the surface.

358. Large animals are as common here as at the surface.
(3.00)

359. (3.00) If there are forms with very large eyes, these animals have developed this condition because they have tried to see in very dim light for many generations.

360. (3.00) The skin coloration (pigmentation) of the forms is quite diverse and many are brightly colored.

361. (3.00) Deep sea fauna (animal life) is characterized by great variation over small areas of the bottom.

362. (3.00) The more life found at the surface the less life found at the abyssal depths.

363. (3.00) Many forms have antennae or feelers of unusual length.

364. (3.00) Herbivores are relatively abundant in the abyssal depths.

365. (3.00) The difference, on the whole, between littoral (shoreline marine) forms and abyssal animal life is greater in the tropics than in the arctic seas.

366. (3.00) Because of the special adaptations necessary for deep sea life, which only a certain proportion of animals have been successful in making, there is a poverty of deep sea forms, bringing about a decrease in competition between species which allows a survival of ancient forms not possible in many other environments.

367. (3.00) Many forms have reduced eyes or no eyes at all.

368. (3.00) On the basis of the various ecological, environmental, anatomical, and physiological factors involved, which of the following organisms would most likely be found living in the vicinity of the North Pole?

A. Turtles. **B.** Frogs. **C.** Water snakes.
D. Protozoa. **E.** Alligators.

369. (3.00) Regions recently overrun by fire will eventually be rehabitated with flora and fauna. Which of the following would probably be the order of resettlement?

A. Small carnivores, large herbivores, small herbivores, green plants, fungi.
B. Fungi, large herbivores, small carnivores, small herbivores, green plants.
C. Green plants, small herbivores, large herbivores, small carnivores, fungi.
D. Fungi, green plants, small herbivores, large herbivores, small carnivores.
E. Small carnivores, fungi, green plants, small herbivores, large herbivores.

370. (3.00) The Venus fly trap, though a green plant, utilizes insects, which it catches between specially modified leaves. But the plant cannot exist entirely on insects. It has all the usual organs of a seed plant. One might predict from this peculiar set of circumstances that

A. the plant is unable to synthesize glucose.
B. there is a deficiency of certain minerals in the soil where the plant lives.
C. the plant lacks the enzymes necessary to digest the starch stored in its leaves.
D. its stomates are so large as to allow excess amounts of water to evaporate; for this plant compensates by capturing insects.
E. the plant is unable to manufacture its own organic foods.

Read the following paragraph carefully and answer items 371 - 390 which follow it.

It has been estimated that 128 California Jack Rabbits eat as much forage as one cow. Since the cost of removing the California Jack Rabbit equivalent of one cow is about $47 (almost twice the value of a range cow) destruction of rodents can hardly be good economy. Moreover, it is probably impossible to estimate the harm that is done by the removal of rodents whose constant burrowing activities are a factor in loosening and aerating the dry soil of the arid southwest. Further, since the inception of the rodent campaign there has been a notable decrease in the number of hawks, which feed on the rodents. With their food supply removed the hawks either resort to killing chickens or leave the region altogether—frequently invading quail game reserves at distant areas. If the rodent control is stopped, and the rapidly breeding rodents begin to multiply again, how will the slowly breeding hawks be replaced rapidly enough to check the rodents?

After each exercise number on the answer sheet, blacken the *one* lettered space which designates the correct answer.

371. (3.00) In this situation, ecological equivalents (animals taking the same things from the environment) are

A. man and rodents. **B.** jack rabbits and cattle.
C. hawks and chickens. **D.** quail and rodents.
E. none of these groups.

372. (3.00) The top carnivores in this situation are

A. cattle. **B.** jack rabbits. **C.** cattlemen.
D. hawks. **E.** quail.

373. (3.00) The key industry animals are

A. chickens. **B.** cattlemen. **C.** hawks.
D. jack rabbits. **E.** none of these.

374. (3.00) Jack rabbits are

A. herbivores. **B.** carnivores. **C.** omnivores.
D. parasites. **E.** none of these.

375. (3.00) Hawks are

A. herbivores. **B.** carnivores. **C.** omnivores.
D. parasites. **E.** none of these.

376. (3.00) The chief value of the rodents is their

A. using weeds as food, thus serving in weed control.
B. eating the same food as rabbits and thus serving in rabbit control.
C. tunneling into the soil and thus loosening the arid soil.
D. being eaten by hawks which otherwise would eat chickens and quail.

377. (3.00) An increased cattle population would *not* result in a decrease in

A. rabbit population. **B.** available forage.
C. soil productivity. **D.** hawk population.
E. quail population.

378. (3.00) The food relationships outlined in this article are indicated by a food chain as follows: (arrows are read as "eaten by")

A. forage → rabbits → rodents → hawks → cattlemen.

B. $$\begin{tikzcd}[column sep=small, row sep=small] & \text{chickens} \arrow[dr] & \\ \text{forage} \arrow[ur] \arrow[dr] & & \text{predator birds.} \\ & \text{quail} \arrow[ur] & \end{tikzcd}$$

C. $$\begin{tikzcd}[column sep=small, row sep=small] & \text{rabbits} \arrow[r] & \text{predator birds} \\ \text{forage} \arrow[ur] \arrow[dr] & & \\ & \text{cattle} \arrow[r] & \text{cattlemen} \end{tikzcd}$$

D. $$\begin{tikzcd}[column sep=small, row sep=small] & & \text{chickens} \arrow[r] & \text{predator birds.} \\ \text{forage} \arrow[r] & \text{rodents} \arrow[ur] \arrow[dr] & & \\ & & \text{quail} & \end{tikzcd}$$

379. (3.00) If the rabbit population were to increase suddenly, the first effect would be seen as

A. an increase in the hawk population.
B. a decrease in the cattle population.
C. a decrease in available forage.
D. an increase in the chicken population.
E. a decrease in the quail population.

380. (3.00) An increase in the hawk population of this area would result in

A. an increase in the cattle population.
B. a decrease in the rodent population.
C. a decrease in the predator population.
D. an increase in the quail population.
E. none of the preceding responses.

381. (3.00) This ecological situation probably occurs in the

A. tundra biome. **B.** deciduous forest biome.
C. desert biome. **D.** grassland biome.
E. coniferous forest biome.

382. (3.00) Some larger animals of this biome are

A. moose, grizzly bear and beaver.
B. caribou, wolf and lemming.
C. black bear, opossum and grey squirrel.
D. prong-horned antelope, badger and coyote.
E. coyote, kangaroo rat and rattlesnake.

383. (3.00) Which of the following groups represent predator-prey relationships?

A. Chickens and quail. **B.** Cattle and forage.
C. Rabbits and hawks. **D.** Forage and rabbits.
E. None of these groups.

384. (3.00) When the presence or absence of a physical or biotic factor determines the presence or absence of a certain organism, this factor is termed

A. an ecological equivalent of the organism.
B. a limiting factor of the organism.
C. an ecological interrelationship of the organism.
D. a principle of cooperation.
E. none of the above responses.

385. (3.00) Which of the following is *not* an important factor in the destruction of forests?

A. Improper lumbering methods. **B.** Soil erosion.
C. Insects. **D.** Careless humans.
E. Critical shortage of planting stock for reforesting.

386. (3.00) Which of the following animals play an important role in reducing soil erosion?

A. Rabbits. **B.** Termites. **C.** Earthworms.
D. Muskrat. **E.** Beaver.

387. (3.00) Which of the following forms the diet of scavenger birds?

A. Seeds. **B.** Insects. **C.** Carrion.
D. Rodents. **E.** Earthworms.

388. (3.00) Which of the following practices would *not* help to conserve soil?

A. Strip cropping.
B. Planting crops in horizontal rows around a slope.
C. Terracing.
D. Planting crops in rows running up a slope.
E. Retention of trees on a steep slope.

389. (3.00) Which of the following are important factors in the decrease of our forest areas?

A. Fires. **B.** Insects. **C.** Grazing.
D. Exploitation. **E.** All of the above.

390. (3.00) In a national park, the rangers have made a practice of systematically killing wolves, coyotes, and mountain lions. Which of the following is the most probable result of this practice?

A. The number of deer reaches the optimum number characteristic of the climax condition.
B. There will be more deer than the area can support.
C. The predators will be benefited.
D. The area will be characterized by little change in its flora.

391. (3.00) Eels, which become adult in freshwater, lay their eggs in the sea; salmon, which become adult in the sea, lay their eggs in freshwater. Which of the following would be adaptive for the eggs of both?

A. Ability to retain water. **B.** Ability to lose water.
C. Impermeable egg shell. **D.** Ability to retain salt.

392. (3.00) Organisms which live at great depths in the ocean are usually animals. Green plants are unable to live there because

A. they have no place there to anchor their roots.
B. they cannot manufacture foods in deep water.
C. the oxygen concentration is too low.
D. they are unable to move about as animals do.

Items 393 - 397.

Directions: For each of the following items concerning the properties of environments, blacken the answer space corresponding to the *one best* alternative.

393. (3.00) An environment which could not be inhabited by any kind of organism is one which lacks

A. access to free nitrogen molecules.
B. access to carbon in any form.
C. access to free oxygen molecules. **D.** access to light.
E. any one of the preceding.

394. (3.00) The environment whose osmotic properties are such that organisms living in it can maintain water balance with the least need for special mechanisms is

A. air. **B.** sea water. **C.** fresh water.
D. soil. **E.** rock.

395. (3.00) One of the major problems to be solved by organisms living in air as opposed to other environmental media, is how to

A. maintain a high water content within cells.
B. obtain food. **C.** dispose of waste materials.
D. maintain an internal temperature adequate for life processes to continue.
E. obtain an adequate supply of free oxygen.

396. (3.00) Water is less suitable than air as an environment for certain forms of organic life in the respect that

- **A.** water has more different chemicals dissolved in it than air has.
- **B.** oxygen is less readily accessible for certain forms in water than in air.
- **C.** more chemical reactions occur between substances in water than between dry substances.
- **D.** combustion of inflammable objects takes place more readily in air than in water.
- **E.** the change in temperature of water is less than of air with a given change in heat.

397. (3.00) An organism is distinct from the non-living environment in which it lives by virtue of

- **A.** its dependence on internal chemical reactions which proceed in "violation" of laws applying to the external world.
- **B.** the inclusion in protoplasm of certain chemical elements which do not occur elsewhere in nature.
- **C.** the delimitation of all visible and microscopically visible parts within the organism by semi-permeable membranes.
- **D.** all of the foregoing. **E.** none of the foregoing.

Items 398 - 411.

Read the following selection carefully. The letters Q, R, S, etc., label paragraphs and sentences referred to by the exercises which follow the selection. The letters which label sentences pertain to the sentences following these letters.

(Q) A study is made over a period of many years in a certain area in the northern part of the country. It was found that there was a moderate amount of rain, a wide seasonal variation of temperature and a growing season of about four months.

(R) In one section there was once a pond in which a sedge mat had grown in toward the center. On this sedge mat and toward the shore around it such plants as cranberry, leatherleaf, and bog rosemary first appeared followed by the later appearance of poison sumach and other larger plants. Tamarack was soon growing in the area, and also spruce and white cedar and jack pine. Hemlock and red pine next became well established here as dominant plants and white pine also. The last increased in numbers and continued to be the predominant plant.

Other plants were, of course, found in the area. (S) The pine-hemlock forest was rather dense and thus the undergrowth was not well developed. Ferns, a few orchids, wintergreen, partridge berry and violets made up a part of the green plants. (T) There were also Indian pipe and coral root, leafless plants which derive their food from the decaying plant and animal tissues on the forest floor. (U) Some of the pines were found to be affected by a fungus growth known as blister-rust. This rust must live a part of its life cycle on currant and gooseberry bushes, the rest of its life cycle on pine. (V) Growing on some of the trees were types of lichen. (W) One small section of the area had been burned over. Aspen and birch had gradually come into predominance.

The animals found in the whole region were quite varied. (X) They include mammals such as deer, elk, bear, and porcupine; birds of many kinds, insects such as beetles, flies, and ants. (Y) The ants are of importance in breaking up (aerating) the soil. (Z) There are also beetles found here which feed upon remnants of animals killed by others for food or animals which have died by other means.

After each exercise number on the answer sheet, blacken the *one* lettered space which designates the correct answer. Refer back to the selection as often as you wish.

398. (4.20) The items listed in paragraph (Q) are

- **A.** physical factors important in determining the types of organisms in an environment.
- **B.** physical factors of little importance in determining the types of organisms in an enviroment.
- **C.** biotic factors of much importance in determining the types of organisms in an environment.
- **D.** biotic factors of little importance in determining the types of organisms in an environment.

399. (4.20) Paragraph (R) describes the process known as

- **A.** regression. **B.** food-chain formation.
- **C.** biotic succession.
- **D.** intraspecific interrelationships.

400. (4.20) In this the pine-hemlock dominants are known as the

- **A.** climax condition. **B.** commensals.
- **C.** key industry plants. **D.** control plants.

401. (4.20) In the condition described in sentence (S) light is a

- **A.** biotic factor. **B.** climax. **C.** factor principle.
- **D.** limiting factor.

402. (4.20) In sentence (T) the plants described are known as

- **A.** commensals. **B.** saprophytes. **C.** climax.
- **D.** parasites. **E.** herbivores.

403. (4.20) In sentence (U) the rust is a

- **A.** symbiont. **B.** saprophyte. **C.** parasite.
- **D.** commensal.

404. (4.20) The lichens indicated in sentence (V) are examples of

- **A.** symbiosis. **B.** parasites. **C.** saprophytes.
- **D.** herbivores.

405. (4.10) The gooseberry and currant are

- **A.** parasites. **B.** commensals. **C.** saprophytes.
- **D.** symbionts. **E.** alternate hosts.

406. (4.20) The best control measure would be to

- **A.** clear pines from the area.
- **B.** prevent pollination of the rust.
- **C.** clear out currant and gooseberry bushes.
- **D.** burn over the area.

407. (4.20) The condition indicated in sentence (W) would be known as

- **A.** an equilibrium. **B.** a climax. **C.** symbiosis.
- **D.** a sub-climax. **E.** a niche.

408. (4.20) The mammals indicated in sentence (X) feed upon plant materials and are therefore known as

- **A.** carnivores. **B.** symbionts. **C.** saprophytes.
- **D.** omnivores. **E.** herbivores.

409. (4.20) Those which kill and feed on animals only are

- **A.** saprophytes. **B.** carnivores. **C.** omnivores.
- **D.** commensals.

410. The earthworm in the deciduous forest performs the
(4.20) same function as the ant mentioned in sentence (Y). These two (ant and earthworm) are spoken of as

A. symbionts. **B.** commensals. **C.** saprophytes.
D. ecological equivalents. **E.** none of these.

411. The beetles indicated in sentence (Z) are considered
(4.20)

A. parasites. **B.** scavengers.
C. key industry animals. **D.** saprophytes.

Items 412 - 423 are based on the following selection. Please read it carefully before answering the items.

The year 1950 . . . is also the 100th anniversary of the landing of the English sparrows in the U. S. Finicky ornithologists regard the immigrants as neither sparrows nor even especially English. They are weaver finches, originally from Africa, and have made a great success in life by attaching themselves, like the dog, the bedbug, and the rat, to the fortunes of man. They colonized Europe long ago, swarming in its cities paved with nutritious refuse. In 1850 they reached Brooklyn.

. . . Brooklyn in those days was plagued by bugs. The shy and decorative native birds did not like city life. As U. S. cities expanded, the birds retired to rural refuges, leaving the shade trees and flower gardens defenseless against insects. Officials of the Brooklyn Institute of Arts and Sciences discussed the problem at length, finally sent to England for an urban bird: the English sparrow.

. . . They found the city a sparrow's paradise. The streets were strewn with the stable midden of the horse-and-buggy age, and under each bright streetlight was a discus of dead bugs.

. . . They . . . soon overflowed Brooklyn. Riding in empty grain cars along the newbuilt railroads, they pioneered the West. By 1886 they had occupied all of the U. S.

Soon there were cries of anguish from U. S. bird lovers. The violent, aggressive English sparrows were too successful. Wherever the sparrows came, bluebirds and wrens got out. Audubon Society members reported heartrending sights of native birds being pursued, insulted, and pecked by sparrows.

. . . Said Biologist Ned Dearborn of the U. S. Biological Survey: "The English sparrow among birds, like the rat among mammals, is cunning, destructive, and filthy."

But by the 1920s the sparrow hosts were already declining . . . Their downfall was not the Audubon Society, but the automobile. As horses grew scarcer and scarcer, sparrows grew scarcer too. Now they survive in cities mostly on the leavings of pigeons.

In some smaller U. S. cities, sparrows are still plentiful. There they have solved their food problem by a kind of inverse commuting. True to their urban traditions, they build their nests in town. In the mornings they fly out to the country to forage in grainfields and barnyards. Then back they commute, full-fed, for the brawling social life in town.

Quoted from TIME Magazine, Vol. LV, No. 15, April 10, 1950, pg. 50.

Directions: For items 412 - 423 select the best answer and mark the corresponding space on the answer sheet.

412. The English sparrows were introduced into Brooklyn
(4.20) in an attempt to solve a problem. This problem was how to

A. dispose of street refuse.
B. lure the native birds back into the city.
C. enable birds to live with human beings.
D. get some kind of bird life re-established in the city for aesthetic reasons.
E. restore something approximating a balance of nature.

413. The introduction of the English sparrow was most simi-
(4.20) lar to

A. a chance occurrence.
B. an experiment without a control.
C. a controlled experiment.
D. a study made under natural conditions.
E. a "shot in the dark."

414. The situation described in the fourth paragraph which
(4.20) arose as a result of the migration of the English sparrows over the United States, was due to

A. a decrease in the total number of birds.
B. an increase in the number of native birds.
C. the inability of the native birds to live in the towns.
D. the inability of the native birds to compete with the English sparrow.
E. the inability of the English sparrow to compete with the native birds outside of the towns.

415. The situation referred to in the preceding item resulted
(4.20) in the

A. formation of some new natural relationships.
B. improvement of some old natural relationships.
C. reconstruction of original natural relationships.
D. abolition of all natural relationships.
E. deterioration of all natural relationships.

416. With the coming of the automobile, the number of
(4.20) English sparrows has decreased because

A. the English sparrows now no longer compete with the native birds.
B. the native birds have increased their ability to compete with the English sparrows.
C. a new factor has been introduced leading to the destruction of the old relationship.
D. a factor in the old relationship has been reduced in importance, leading to the development of a new relationship.
E. the English sparrow is not a native bird.

417. The new "commuting habits" of some English sparrows
(4.20) indicate

A. an adjustment of the species in connection with the attainment of a new relationship.
B. an attempt by the English sparrow to maintain the old relationship.
C. that the species is on the way to becoming extinct in America.
D. that the species is again increasing to its former numbers.
E. that the English sparrow is becoming a country bird rather than a city bird.

418. The statement by Dearborn, "The English sparrow
(4.20) among birds, like the rat among mammals, is cunning, destructive and filthy," is

A. an hypothesis. **B.** a guess.
C. a verified conclusion. **D.** an opinion.
E. an established fact.

419. On the basis of the article, the statement that the English sparrow is a bird which is associated with human dwellings, towns, and cities would be
(4.20)

A. an hypothesis. **B.** an assumption.
C. a conclusion. **D.** a theory.
E. an unwarranted assertion.

420. On the basis of the article, a statement that the English sparrow may be expected to become a permanent component of the bird life of temperate North America, would be
(4.20)

A. a reasonable hypothesis. **B.** an assumption.
C. an unwarranted assertion. **D.** a proved fact.
E. an unwarranted conclusion.

421. The most effective method of testing the validity of the statement given in item 420 would be to take a census of
(4.20)

- **A.** all English sparrows in ten American cities of different sizes.
- **B.** all native birds in ten American cities of different sizes.
- **C.** all birds, including English sparrows, in ten American cities of different sizes.
- **D.** all birds, including English sparrows in ten American cities of different sizes, and in a ten-mile zone around each city.
- **E.** all birds, including English sparrows, in ten American cities of different sizes, and in a ten-mile zone around each city, at ten-year intervals.

422. In evaluating the factors which will determine what part various species will play in the total bird population of the United States 100 years from now, a scientist expects that
(4.20)

- **A.** the native species will eventually triumph.
- **B.** man will determine which species survive and which do not.
- **C.** the influence of the Audubon Society and other bird-lovers will weigh strongly in favor of the native species.
- **D.** those species will survive and increase which are best able to do so in competition with others in the environment which man has modified.
- **E.** in this length of time there will be new species that are better adapted to man-modified conditions which will evolve and replace those which are now here.

423. Between 1850 and 1950 which one of the following was the most important in the solution of the problem resulting from the introduction of the English sparrow?
(4.20)

- **A.** Increase and decrease in the number of English sparrows.
- **B.** Decrease in the number of other birds in towns.
- **C.** Relationship of other birds to English sparrows.
- **D.** Change in the food habits of the English sparrows.
- **E.** Relationships of native birds, English sparrows, horses, and human beings to one another.

Items 424 - 443 are concerned with the ecological interrelationships which prevail in a plant community. Before attempting to answer these items consider the graph and the following data.

- a. The presence of grass in some way interferes with the growth of weeds.
- b. Similarly, the presence of weeds interferes with the growth of bluegrass.
- c. Grass seeds germinate more readily than weed seeds in the autumn.
- d. Weed seeds germinate and grow faster than grass in the spring.
- e. Trees with low branches may interfere with the growth and dominance of bluegrass, but if all the branches of a tree are high above the ground, bluegrass may continue to grow indefinitely beneath it.
- f. Since each plant in a lawn is influenced in some way by the presence of other plants, the relative abundance of bluegrass or of any other species of plant in the lawn may not remain the same from year to year.
- g. One plant species may be entirely eliminated and replaced by another species.
- h. Bluegrass will not flourish where the area in question is very wet, very dry, very acid, sandy, shaded, or deficient in nitrogen, or where the soil temperatures are very high in summer.
- i. Of the substances commonly added to lawns, shredded peat moss increases acidity, while bone meal or lime increases the alkalinity.
- j. Kentucky bluegrass is most likely to become dominant in lawns with moderate moisture and temperature, abundant light, and loamy soils that are slightly acid but rich in salts of nitrogen, phosphorus, and potassium.
- k. Bent and fescue grasses will grow better in soils of greater acidity than will bluegrass.
- l. Fescue grass will tolerate shade much better than bluegrass.
- m. Bermuda grass grows better in areas where high soil temperatures prevail.
- n. Fescue and redtop grasses can tolerate much drier conditions than bluegrass can.
- o. Bentgrass requires more moisture than bluegrass, redtop, or fescue grasses.
- p. Bent and fescue grasses grow well in soils of greater acidity than bluegrass.

Mark items 424 - 433 according to the following key:

The conclusion

- **A.** *is warranted* by the foregoing data and/or graph.
- **B.** *is contradicted* by the foregoing data and/or graph.
- **C.** goes beyond the foregoing data and/or graph but is true according to basic biological principles.
- **D.** goes beyond the foregoing data and/or graph and is false according to basic biological principles.

424. The situation whose data is portrayed in the graph was located in a region of very high soil temperature.
(4.20)

425. The grass plot described in the graph experienced a continual shift of dominant species during the first four years.
(4.20)

426. The grass plot described in the graph apparently grew in a region of subdued light.
(4.20)

427. The change in plant population in the grass plot was brought about by mutation.
(4.20)

428. The grass plot illustrates ecological *succession.*
(2.10)

429. The grass plot was apparently located in a low area where the rainfall was very heavy.
(4.20)

430. The ultimate dominant species in the grass plot was bluegrass.
(4.20)

431. The white clover harbors organisms which improve the habitat for the bluegrass.
(4.20)

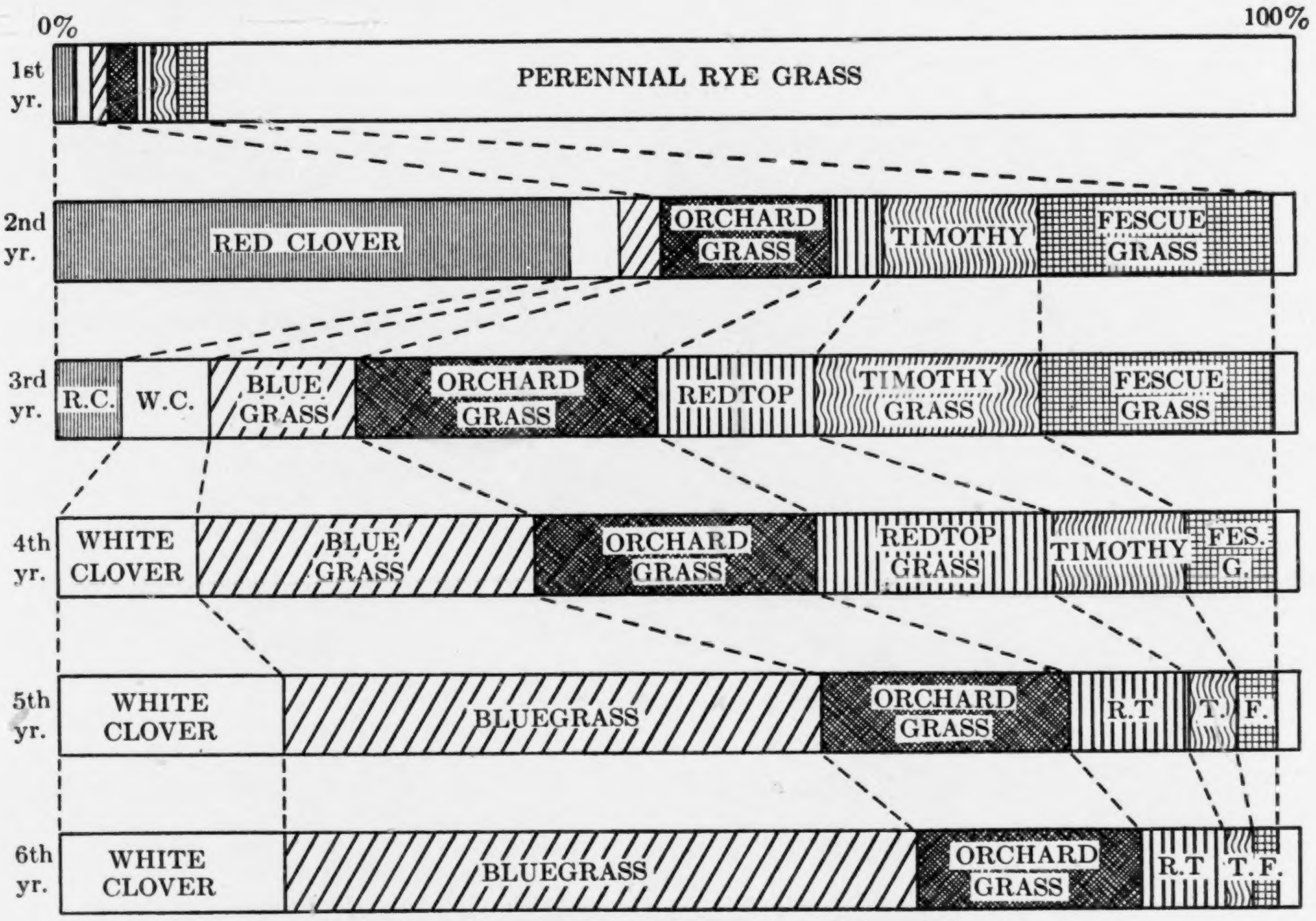


Diagram of changes that occurred in a mixed population of plants in an experimental plot during a period of five years following the first year, when the seeds were sown with those of a nurse crop (perennial rye grass). The comparative yield of each kind of plant from year to year is given. (Data from R. G. Wiggans. Cited in Transeau, Sampson and Tiffany—*Textbook of Botany*).

432. (4.20) The best time to seed a new lawn in the North Central States is in the spring of the year.

433. (4.20) Addition of lime would further accelerate the growth of bluegrass in the above plot after the sixth year.

434. (4.20) It is impossible to get any kind of grass to grow under trees which have a dense crown of leaves and low hanging branches.

435. (4.20) Bluegrass requires more sprinkling in summer than any other kind of grass.

436. (4.20) Bermuda grass would probably grow better than Kentucky bluegrass on a golf green is Central Michigan.

437. (4.20) A legume was completely eliminated from the above plot by the fourth year.

438. (4.20) Application of ground bone meal would have stimulated the fescue grass in the grass plot to make a relative increase in six years instead of the decrease shown in the graph.

439. (4.20) In the grass plot most atmospheric nitrogen was made available to the plants during the second year.

440. (4.20) The presence of bluegrass has a stimulating effect on the growth of timothy in a pasture.

441. (4.20) The presence of clover in a lawn will intensify the green color of the bluegrass in the same lawn.

442. (4.20) Fescue grass is more adversely affected by the presence of bluegrass than is orchard grass.

443. (4.20) Lawns, pastures and parks everywhere in Central and Southern Michigan will, in course of time, become completely dominated by bluegrass.

PINE — APHIDS (plant lice) — SPIDERS — SMALL BIRDS — HAWKS
(1) (2) (3) (4) (5)

Items 444 - 449 refer to the preceding food chain. For each numbered item blacken the space of the response that best completes the sentence.

444. (4.20) The aphids are

A. key industry animals. **B.** carnivores.
C. symbionts. **D.** saprophytes. **E.** scavengers.

445. (4.20) The top carnivore is

A. an aphid. **B.** a spider. **C.** a small bird.
D. a hawk.

446. (4.20) If an epidemic disease destroyed most spiders,

A. the aphids would decrease in number.
B. the pines would increase.
C. the small birds would increase.
D. it would have no effect on the numbers of any of the organisms.
E. the aphids would at first increase in number.

447. (4.20) The greatest number of animals under conditions of balance would be included in group

A. 2. **B.** 3. **C.** 4. **D.** 5.

448. The smallest animals would be included in group
(4.20)

A. 2. B. 3. C. 4. D. 5.

449. Elimination of any member in the above scheme would result in
(4.20)

A. an increase in all of the remaining members.
B. no change. C. parasitism.
D. death of all members. E. unbalance in nature.

Items 450 - 468.

Life in a cave provides an interesting study in the relationships which exist among living things. The only food source for cave animals may be provided by bats which go out at night to feed on flying insects, and which return for the day, and build a guano of droppings on the cave floor. The walls of the cave where the bats cling are almost sure to be sparsely populated with bat bugs—relatives of the bed bug which suck the blood of bats. Small blood-sucking flies are other inhabitants of the same places. The droppings of the bats are rich in food values, and in the moist air form a suitable medium for molds. This constitutes a plant substrate on which cave crickets feed—and other insects, spiders, and scorpions eat the cave crickets. A rise in mold is followed by a rise in cricket numbers, which reduces the mold until many of the crickets starve to death and fertility falls off. This event gives the mold a new start. Thus a balance is struck between too many and too few crickets, but this in turn is governed by the mold, which in turn depends upon the bats. If the bats leave the cave in favor of hollow trees during the summer, or hang up dormant for the winter, their droppings no longer accumulate, the mold no longer thrives, the cave crickets starve, and the creatures which eat them do likewise. Energy from the outside world is transferred by the insect bodies incompletely digested by the bats.

After each exercise number on the answer sheet, blacken the *one* lettered space which designates the correct answer, or the best answer.

450. The above paragraph illustrates
(4.20)

A. symbiosis. B. succession. C. a food chain.
D. no need for green plants. E. none of these.

451. The top carnivores in this situation are
(4.20)

A. insects eaten by bats. B. the crickets.
C. the bat bugs. D. the molds.
E. the spiders and scorpions.

452. The key industry animals are the
(4.20)

A. scorpions. B. cave crickets. C. bats.
D. bat bugs. E. spiders.

453. The crickets are
(4.20)

A. parasites. B. herbivores. C. carnivores.
D. omnivores. E. none of these.

454. The bat bugs are
(4.20)

A. parasites. B. herbivores. C. carnivores.
D. omnivores. E. none of these.

455. An increase in the bat population would result in
(4.20)

A. an increase in outside insect population.
B. a decrease in mold growth.
C. a decrease in bat bug population.
D. an increase in cricket population.
E. none of the above.

456. Which of the following groups represent predator-prey relationships?
(4.20)

A. Crickets and mold. B. Spiders and crickets.
C. Bats and bat bugs. D. Bats and crickets.
E. Bats and scorpions.

457. In this situation, ecological equivalents (animals taking the same things from the environment) are
(4.20)

A. spiders and crickets. B. bats and bat bugs.
C. spiders and scorpions. D. bat bugs and crickets.
E. scorpions and crickets.

458. The ultimate source of energy for this series of relationships is the energy
(4.20)

A. stored in animal bodies.
B. stored in the bat droppings.
C. from the sun stored in green plants.
D. produced in the mold growth.
E. stored in bodies of insects living outside the cave.

459. The food relationships in this series are best indicated by a food chain as follows: (Arrows are read as "food for.")
(4.20)

A. Bat droppings → mold → crickets → spiders and scorpions.
B. Green plants → insects → bats → bat droppings → mold → crickets → spiders and scorpions.
C. Green plants → bats → insects → bat droppings → mold → crickets → spiders and scorpions.
D. Bats → mold → spiders and scorpions → crickets.
E. Spiders and scorpions → crickets → mold → bat droppings.

460. Probably the most important factor limiting animal populations in the caves is
(4.20)

A. food supply.
B. naturally low reproductive rates of the animals themselves.
C. inadequate water supply.
D. low temperatures. E. numerous parasites.

461. Many white animals flourish amid the Arctic snow. This is probably the result of
(4.20)

A. none of the following.
B. the type of food they eat. C. natural selection.
D. sexual selection. E. artificial selection.

462. The vegetation on a bare rock proceeds through the years from lichens to mosses, then to ferns (in the rock crevices), then to other herbaceous plants, and finally to trees, which continue as permanent inhabitants of the area. This is an example of
(4.20)

A. succession. B. adaptation. C. a hydrosere.
D. selection. E. a food chain.

463. The number of predators is influenced by
(4.20)

A. reproductive rate.
B. the presence of internal parasites.
C. epidemics. D. the number of herbivores.
E. all of the above.

464. In a burned-over area, one of the first plants to come in is fireweed (Epilobium), but it disappears as other vegetation moves in. Variation in which of these factors is
(4.20)

responsible for the fireweed being replaced by other vegetation?

A. Acidity of the soil. **B.** Bright sunlight.
C. Amount of moisture in the soil.
D. Amount of humus in the soil.
E. More than one of the above.

465. (4.20) In some parts of North Dakota no trees grow naturally and people have tried unsuccessfully to get them to grow. This is true because

A. the right trees haven't been tried.
B. the light is too intense.
C. the winds are too strong.
D. there is insufficient moisture.
E. predators destroy them.

466. (4.20) An environmental factor which is *not* limiting in its effect upon the distribution of present-day vegetation in nature is

A. amount of light. **B.** quality of light.
C. amount of CO_2 in the air.
D. amount of moisture.
E. chemical composition of soil.

467. (4.20) Certain species of desert lizards excrete their wastes in dry form. This represents

A. a limiting factor of the organism.
B. adaptation of the organism to environment.
C. a protective device against enemies.
D. the result of malnutrition.
E. none of the above.

468. (4.20) Often introduced species of plants and animals become pests in their new homes, although they were not pests in their native habitats. The most important reason for this is that

A. they may reproduce in large numbers.
B. they can resist adverse climatic conditions.
C. they are free from natural enemies.
D. they may adapt to new food supplies.
E. All of the above are equally important.

25. *Evolution—*
History of Life on the Earth—Adaptation

EVOLUTION—HISTORY OF LIFE ON THE EARTH—ADAPTATION

1. (1.10) Qualities or peculiarities of structure developed by an organism as a result of environment or of use and disuse of organs

- **A.** are due fundamentally to mutation.
- **B.** are designated as acquired characters.
- **C.** are called unit characters.
- **D.** are spoken of as dominant characters.
- **E.** constitute substantiating evidence for the theory of evolution.

2. (1.10) The belief that life can arise from non-living matter is known as

A. organic evolution. **B.** spontaneous generation.
C. asexual reproduction. **D.** survival of the fittest.
E. binary fission.

3. (1.10) One probable ancestor of our modern corn plant is

A. the sorghum plant. **B.** tripsacum. **C.** barley.
D. cinchona. **E.** a legume.

4. (1.10) Of the following living organisms the lowest form would be

A. bacteria. **B.** virus. **C.** blue-green algae.
D. amoeba. **E.** mite.

5. (1.10) There is living on the earth at the present time only one species of

A. ape. **B.** bear. **C.** monkey. **D.** dinosaur.
E. man.

6. (1.10) The repetition of body parts such as vertebrae, paired ribs, nerves and blood vessels throughout the length of man illustrates

A. cephalization. **B.** morphology.
C. segmentation. **D.** differentiation.
E. bilateral symmetry.

7. (1.10) The most accurate method at present of estimating geological time:

- **A.** Chemical analysis of rocks.
- **B.** Decomposition of radioactive materials (uranium-lead).
- **C.** Study of sedimentation rates.
- **D.** Comparisons with known historical phenomena.

8. (1.10) It is thought that modern man developed from

A. Neanderthal man. **B.** great apes. **C.** Java man.
D. Cro-Magnon man. **E.** super man.

9. (1.10) In the following pair, blacken space A if the first element of the pair is definitely greater than the second; space B if the second is definitely greater than the first; and space C if the two are approximately equal.

1. Estimated years since Cro-Magnon man lived.
2. Estimated years since Java man lived.

10. (1.10) In the following pair, blacken space A if the first element of the pair is definitely greater than the second; space B if the second is definitely greater than the first; and space C if the two are approximately equal.

1. Average size of modern horses.
2. Average size of primitive horses.

11. (1.10) Body structures which are fundamentally alike and develop in the same way are said to be

A. analogous. **B.** homologous. **C.** homogeneous.
D. heterogeneous. **E.** embryological.

12. (1.10) Any actual remains, molds, casts, or tracks left by a plant or animal of past geologic times is called a

A. geological object. **B.** archeological object.
C. proof of evolution. **D.** fossil. **E.** petrification.

13. (1.10) A vestigial organ is one that is

- **A.** in the process of developing into a useful organ.
- **B.** of great physiological importance.
- **C.** in the process of deterioration.
- **D.** found only in the embryo.
- **E.** peripherally located.

Items 14 - 18. From the following key list, select the one term which is best defined in each of the following items.

KEY

A. isolation. **B.** genetic drift. **C.** gene mutation.
D. genetic recombination. **E.** natural selection.

14. (1.10) A source of variation whose importance is greatly enhanced through the occurrence of bisexual reproduction in the great majority of plants and animals.

15. (1.10) A necessary preliminary to the splitting of a freely-interbreeding population into sub-populations whose gene frequencies differ from that of the original one.

16. (1.10) An evolutionary factor operative in small populations to eliminate some allelic genes through pure chance.

17. (1.10) A factor which operates to eliminate individuals less adapted than their competitors in a given environment.

18. (1.10) A possible source of variation which, in many cases, may not be evident phenotypically unless present in enough individuals of a population so that it can become homozygous.

Items 19 - 23. Identify each of the following with one of the men named in the key list below:

KEY

A. Weismann. **B.** Wright. **C.** Wallace.
D. Galton. **E.** Malthus.

19. (1.10) Genetic drift.

20. (1.10) Continuity of germ plasm.

21. (1.10) Nature and nurture.

22. (1.10) Population growth and food supply.

23. (1.10) Evolution through natural selection.

Items 24 - 27. Select the answer to each of these items from the following key list:

KEY

A. cleavage. **B.** somite formation. **C.** blastula.
D. coelom formation. **E.** gastrula.

24. (1.10) The structural plan of Hydra (a simple coelenterate) corresponds most nearly to which stage in embryonic development of higher animals?

25. (1.10) Which stage corresponds most nearly to the arrangement of the cells in structural organization of Volvox (a colonial protozoan)?

26. (1.10) On the basis of structural complexity, which stage represents the most recent evolutionary development?

27. (1.10) Annelids, such as the earthworm, are at a level of organization that corresponds most nearly to which stage?

28. (1.10) The wings of a grasshopper and the wings of an eagle are

A. biramous. **B.** analogous. **C.** homologous.
D. dichotomous. **E.** homozygous.

29. (1.10) Of the following animals the one now extinct is the

A. buffalo. **B.** passenger pigeon. **C.** wild turkey.
D. prairie chicken. **E.** wolverine.

30. (1.10) According to the theory of *orthogenesis,* organisms

A. tend to evolve in relation to the environment.
B. possess an inherent tendency for continued change in a definite direction.
C. were created in their present form.
D. change in relation to natural laws.
E. compete with each other and thus are preserved or eliminated, depending on whether or not their particular characters have "survival value."

31. (1.10) The first seedless grapefruit may have made its appearance as a result of

A. inbreeding. **B.** self-pollination.
C. natural selection. **D.** hybridization. **E.** mutation.

32. (1.10) The subsequent generations of seedless grapefruit are made available to us in quantity by means of

A. vegetative propagation. **B.** cross-pollination.
C. hybridization. **D.** outbreeding.
E. survival of the fittest.

33. (1.10) During embryonic development every animal goes through developmental stages that correspond to evolutionary stages which the ancestors of the animal have passed through. This is the theory of

A. evolution. **B.** cultural inheritance.
C. anthropological and archeological descent.
D. recapitulation. **E.** racial regression.

34. (1.10) Which of the following features of bird construction developed most recently?

A. Claws. **B.** Egg-laying. **C.** Feathers.
D. Hollow bones. **E.** Scales on legs.

35. (1.10) Which of the following principles is illustrated by the appendages of the crayfish?

A. Serial homology. **B.** Metagenesis.
C. Metabolism. **D.** None of these.

36. (1.10) Who was the author of the "The Origin of Species by Means of Natural Selection"?

A. Lamarck. **B.** Wallace. **C.** de Vries. **D.** Darwin.

37. (1.10) Which of the following men was closely associated with the advancement of the mutation theory of evolution?

A. Lamarck. **B.** Wallace. **C.** de Vries. **D.** Darwin.

38. (1.10) Which one of the following eras is the most recent?

A. Mesozoic. **B.** Cenozoic. **C.** Proterozoic.
D. Archeozoic.

39. (1.10) Which system has undergone a relatively great increase in the tapeworm?

A. Nervous. **B.** Digestive. **C.** Excretory.
D. Reproductive.

40. (1.10) Which of the following are considered the first land vertebrates?

A. Birds. **B.** Amphibians. **C.** Reptiles.
D. Mammals.

41. (1.10) Fossils are usually not found in which of the following rocks?

A. Metamorphic. **B.** Sedimentary. **C.** Limestone.
D. Sandstone.

42. (1.10) Which of the following is considered the most specialized?

A. The foot of a man. **B.** The foot of a dog.
C. The foot of a cow. **D.** The foot of a horse.

43. (1.10) The idea that ontogeny recapitulates phylogeny was suggested by studies in

A. Embryology. **B.** Taxonomy. **C.** Physiology.
D. Paleontology.

Darwin states that the environment produces variations directly on the body or indirectly by affecting the germ cells. When the environment produces similar changes on many individuals, Darwin calls this definite variation. Indefinite variation, on the other hand, refers to the fact that changed conditions affect different individuals differently. The following statements are incomplete and can be completed by adding *one* or *more* kinds of variation. *Blacken answer space*

A. when *direct variations* belongs in the blank.
B. when *indirect variations* belongs in the blank.
C. when *definite variations* belongs in the blank.
D. when *indefinite variations* belongs in the blank.

Note: *All* correct alternatives should be selected for the following items, and the scoring is right minus wrong.

44. (1.10) According to Darwin, ________ are practically always adaptive.

45. (1.10) According to Darwin, ________ are inheritable.

46. (1.10) According to Darwin, ________ are most predictable.

47. (1.10) According to Darwin, ________ are most important in origin of domestic races and species.

48. (1.10) The kind of variation Weismann argued could not be inherited is________.

49. (1.10) The term most closely related to East's term, "fluctuation," is________.

50. (1.10) The term(s) most closely related to Timofeeff's term, "mutation," is (are)________.

51. (1.10) According to Darwin, the relation of origin of domestic breeds to origin of natural species is as follows:

A. Domestication facilitates variation, i.e., variation is artificially enhanced; in all other respects the origin of domestic breeds is identical to origin of species.
B. The "laws" of heredity are not strictly adhered to in domestic breeds (i.e., greater likelihood for reversion); in all other respects origin of breeds is identical to origin of species.
C. Variation alone cannot account for origin of domestic breeds, since domestic breeds are peculiarly suited to man's fancy and not to nature. The definite action of external conditions would be much more crucial in the origin of species.
D. The roles of variation and selection are the same in both cases—the causes of variation and selection in nature are different from the causes of variation and selection in art.
E. If you substitute "struggle for existence" for "man's selection" and "geographical isolation" for "artificial isolation," the origin of species is identical to the origins of domestic breeds.

52. (1.20) Darwin notes that in comparing *domestic* breeds of cabbage, they are alike in non-useful characters (flowers) but are diverse in useful characters (leaves). This shows Darwin that one would expect that (select *all* correct alternatives)

A. useful characters are most valuable for classifying natural species.
B. natural selection can operate only on certain characteristics of organisms.
C. in Nature, the characters most important in showing common ancestry may have little adaptive significance.
D. the slightest individual variation in Nature can, if it has differential survival value, be accumulated to such an extent that different races or varieties result.
E. varieties in Nature would be alike in adaptive characters and unlike in non-adaptive characters.

53. (1.10) According to Darwin, in order to explain the origin of species by evolution, it is absolutely necessary that (select *all* correct alternatives)

A. there be an orderly relation between parents and offspring.
B. some variations may be perpetuated indefinitely.
C. environment have a "definite" effect on the organism.
D. somatic changes due to habits are inheritable.
E. very minute variations have differential survival value.

54. (1.10) The chief and most general cause for the limitation in the number of a species is

A. epidemics.
B. direct action of the environment—extreme cold, drought.
C. limitations in food supply.
D. competition with other species.
E. the degree of organization and specialization possible in the highest species.

55. (1.20) Darwin can explain the fact that some simple one-celled species have remained unchanged throughout almost the entire history of living organisms by showing that

A. certain niches in the natural economy are most adequately filled by simple organisms.
B. in some places there has been no change in the physical environment.
C. some organisms have no inherent tendency to vary.
D. there is no competition among simple organisms.
E. more complex organisms depend on simpler organisms for their food supply.

56. (1.10) Darwin explains the advancement in organization of the greater number of living beings on the grounds that

A. most variations tend to increase the level of organization.
B. the physical environment has become more and more complicated.
C. species with advanced organization usually win out in competition with species with less advanced organization.
D. the more highly specialized species are more flexible, i.e., they are more likely to survive geological changes in the physical environment.
E. the total amount of life that can be supported is proportionate to the number of distinct niches occupied, i.e., to the degree of specialization.

Note: Consider items 57, 58, and 59 as a unit.

57. (2.20) The facts which have the greatest significance in shaping the character of present-day theory of evolution as distinguished from Darwin's theory depended on the discovery of

A. Hardy's rule. **B.** segregating hereditary units.
C. statistical methods for analyzing populations.
D. the continuity of the germ plasm.
E. individual variations which are not caused by the environment.

58. (2.20) The implication of this discovery (item 57) is that

A. evolution must come to a standstill.
B. all inherited variation consists in differences in genes.
C. the variability of populations can be treated precisely by using the "standard deviation."
D. characters acquired by use or disuse are not heritable.
E. evolution must be a matter of chance.

59. (2.20) This implication, i.e., the correct alternative in item 58, must be qualified in the light of evidence that

A. mutation pressure prevents genetic uniformity.
B. the arrangement or position of genes and polyploidy have an effect on phenotype and are heritable.
C. $\sigma\Delta_q$ is a more pertinent statistic than σ in the field of population genetics.
D. habits can affect plasmogenes by changing the physico-chemical environment of the cytoplasm.
E. selection has a greater significance than variation for certain sized populations.

60. (1.10) Timofeeff *differs* from Darwin in holding that

A. variation provides the raw material for evolution and is not a directive factor in evolution.
B. only heritable variations are important for evolution.
C. not all classes of variation are heritable.
D. slight individual differences do not have differential survival value.
E. selection is a stabilizing factor in evolution.

Note: Consider items 61 and 62 as a unit.

61. (2.20) Timofeeff asks whether all heritable variation can be classified as mutation. This question is answered in the affirmative if all heritable individual differences

A. are spontaneous. **B.** are discrete or discontinuous.
C. behave like the constant differentiating characters of Mendel's experiments.
D. are a result of random samplings of the parental store of genes.
E. are a result of chemical changes in the nucleus of the germ cell.

62. (2.20) The criterion for mutation which constitutes the proper answer to item 61 is, in fact, too stringent. It would have to be modified to allow for the existence of

A. chromosomal aberrations.
B. X-ray-induced mutation.
C. nucleo proteins in the cytoplasm which have the capacity for self-duplication.
D. multiple factor inheritance and, in general, interaction between genes.
E. mutations whose effects are too slight to be measured.

63. (2.30) Timofeeff asks whether mutations have all those qualities which must be assumed in order to explain their role as evolutionary material. In order to answer this question in the affirmative, it would *not* be necessary to show that mutations

A. are for the most part adaptive.
B. produce differences in relative viability.
C. are present in sufficient number in free-living populations.
D. include all kinds of physiological and morphological characters.
E. must remain stable almost indefinitely—which means, of course, that mutation is a rare event.

64. (2.20) The typical relation between the viability of wild-type and mutant genes shows that

A. the least fit organisms do not survive as well as the more fit.
B. in any natural economy there are always new niches which potentially provide better support than present niches.
C. most species are occupying "adaptive peaks" in Wright's sense of the term.
D. nature prefers "extremes" (in Darwin's sense), and thus divergence of character is brought about by the extinction of intermediates.
E. an individual mutation has a very small chance of surviving in a large random-breeding population.

65. (1.10) All individuals are genotypically different, but not every individual difference has been used in the process of evolution. According to Timofeeff, a mutation has been used in the process of evolution if it

A. is common to many individuals thereby constituting the criterion for, or means of defining, a class.
B. has physiological significance or adaptive value.
C. prevents individuals possessing it from mating with members of the same species who do not possess it.
D. is distributed throughout a particular ecological area.

66. (2.30) According to Timofeeff, if mutations really participate in the formation of taxonomic groups, one could predict that (select *all* correct alternatives)

A. certain known mutations will be found to be restricted to individuals occupying a common geographic area.
B. when two groups have been distinguished as separate races, crossing members of the two races will produce sterile hybrids.
C. when two groups have been distinguished as separate races, crossing members of the two races will result in hybrids which are intermediate to their parents in all the traits which distinguish the parents.
D. when two groups have been distinguished as separate races, crossing members of the two races will result in an F_2 population (bred from the F_1 hybrid) in which the grandparental traits will be recovered.
E. within the same species, partially isolated populations would show marked differences in the gene frequency of certain alleles.

67. (1.10) According to Wright, "mutation" is the obvious starting point in the attempt to relate genetics to evolution since

A. every mutation gives rise to a new species.
B. mutation is the unit of inheritable variation.
C. according to Mendel, all individual differences are due to mutation.
D. mutation pressure is the only way the gene frequency of a population can be changed.
E. mutation is defined as a change in the x chemical or molecular structure of a gene.

68. (2.30) If an attempt is made to define unequivocally a "natural taxonomic unit"—i.e., species—solely in terms of morphological similarity (i.e., homology), one encounters the insurmountable difficulty of determining

A. which morphological characters have been and which characters will be of evolutionary significance.
B. which racial differences can and which cannot be attributed to selection.
C. when a difference between groups is large enough to be called a difference in species and not merely varieties.
D. whether one mutation or more than one mutation is required to merit the rank of species difference.
E. whether any one morphological difference is due to one, or more than one, mutation.

69. (1.10) Wright solves the "problem of defining a species" by

A. denying that species are the "natural taxonomic units" and by asserting instead that the difference between species and varieties is arbitrary.
B. showing that the critical step in the "hierarchy of degrees of difference in kind" must be identified with more than one mutation.
C. introducing a geographical or spatial dimension so that the definition of species includes the notion of a common area of distribution.
D. showing that species must be identified with distinct *ecological* niches—i.e., speciation occurs only when selection has operated.
E. adding the criterion of interbreeding population to the definition of species so that the adequate genetic description of a species is a series of gene frequencies.

70. (2.30) According to Wright, if race 1 breeds with 2, 2 with 3, 3 with 4, but 1 and 4 do not interbreed, then 1 and 4 may be said to be in the same species in the sense that

A. races 1 and 4 would interbreed if they occupied the same territory.

B. many genes are common to races 1 and 4.
C. races 1 and 4 occupy the same ecological niche.
D. the frequencies of the genes in race 1 are the same as the frequences of the genes in race 4.
E. any gene in race 1 has the possibility of being transmitted to race 4.

71. (2.10) The elementary evolutionary process, according to Wright becomes Δq rather than a single mutation because

A. a single mutation can be of little importance in speciation, whereas a change in q always leads to a new species.
B. the difference between species never lies in the presence or absence of certain genes but in the values of q for a large number of genes.
C. the origin of species depends on several factors which can be considered simultaneously in terms of their effect on q.
D. single mutations often have no effect on appearance and of those mutations which do change character, many are neutral or mal-adaptive; Δq, however, is sensitive to any change in the average adaptive value of a genotype.
E. in order to get a difference between groups large enough to merit the rank of species, there must be a large number of characters distinguishing the groups.

72. (2.30) Wright classifies theories of evolution according to the demands which they place on chance events. The role of chance is *least* in theories which postulate that

A. mutation is caused by the environment.
B. variations important for evolution are adaptive.
C. mutations are for the most part mal-adaptive and cannot account for the origin of species.
D. the factors which determine which individuals become parents of the next generation are in part selective and therefore only in part accidental.
E. inherited variations correspond or are "appropriate" to their causes and are thus not accidental.

73. (1.10) Darwin considers that intercrossing plays two important roles in evolution, namely (give the two correct answers)

A. it decreases the amount of divergence from "type" of individuals of a species.
B. it increases the number of combinations of traits in the individuals of a species without increasing the number of kinds of hereditary units.
C. it renders individuals less vigorous and less able to compete with individuals in other species.
D. it increases the probability of reversion to ancestral types.
E. it permits the spread of favorable new variations throughout a population.

74. (1.10) Darwin postulated that, in order to be capable of being inherited, a variation must

A. appear for the first time in the germ line.
B. be the result of use or disuse.
C. be the definite result of changed conditions of life.
D. be a very small departure from the species type.
E. None of the foregoing, since he admitted ignorance as to the cause of inheritable variations.

Geological times in order, the most recent first in the list:

A. Cenozoic. **B.** Mesozoic. **C.** Late Paleozoic.
D. Mid Paleozoic. **E.** Early Paleozoic.

During which of these did the following first appear?

75. (1.10) Amphibia.
76. (1.10) Birds.
77. (1.10) Fishes.
78. (1.10) Mammals.
79. (1.10) Reptiles.

Items 80 - 86. Theories of evolution:

A. Germinal selection.
B. Inheritance of acquired characteristics.
C. Mutation. **D.** Natural selection.
E. Orthogenesis.

Which of the men named below was particularly influential in the development of the theories?

80. (1.10) Darwin.
81. (1.10) DeVries.
82. (1.10) Eimer.
83. (1.10) Lamarck.
84. (1.10) Nageli.
85. (1.10) Wallace.
86. (1.10) Weismann.

Items 87 - 91. Appendages of crayfish.

A. First abdominal appendage.
B. Second walking leg. **C.** Third walking leg.
D. Third abdominal appendage. **E.** None of these.

87. (1.10) Which lacks an endopodite?

88. (1.10) Which has an exopodite?

89. (1.10) Which lacks a protopodite?

90. (1.10) Which has a claw?

91. (1.10) Which is different in male and female?

92. (1.10) Which of the following seems to have been the place of origin of the camels?

A. Europe. **B.** Asia. **C.** Africa.
D. North America. **E.** None of the above.

93. (1.20) Prehistoric insects became trapped in gummy materials exuding from certain trees. Hardening of the material preserved the insects until present day. This illustrates a fossilization process known as

A. carbonation. **B.** embalming. **C.** petrification.
D. moulding. **E.** replacement.

94. (1.20) The earliest evolutionary advance beyond the single-celled protozoa probably was the

A. arrangement of cells in layers.
B. segmentation of body parts.
C. differentiation of certain cells for division of labor.
D. aggregating cells of the same type.
E. addition of an external limy skeleton.

95. When we consider the problem of plant and animal
(1.20) evolution and the problems of modern plant and animal life, the greatest evolutionary step probably was the

A. specialization of the protoplasm so as to free it from a water environment.
B. differentiation of the protoplasm into cellular form.
C. development of nerve tissue.
D. differentiation of the endoderm, mesoderm, and ectoderm.
E. development of the ability to use the energy of the sun.

96. Four of the following are vestigial structures in man.
(1.20) Which one is *not* vestigial?

A. The muscles for moving the outer ear.
B. Extreme hairiness of the chest.
C. The vermiform appendix.
D. The nictitating membrane.
E. The gall bladder.

97. The appearance of gill slits in the early embryonic de-
(1.20) velopment of all chordates would indicate

A. that developing mammalian embryos, surrounded by embryonic fluids, apparently breathe by means of gills.
B. that fish, amphibia, reptiles, birds and mammals are probably descendants of the same common ancestor.
C. that vestigial structures have a function in early embryonic development.
D. that the origin of life can be traced by means of the theory of evolution.
E. that phylogeny recapitulates ontogeny.

98. The most accurate method for estimating the age of
(1.20) the earth may be associated with the fact that

A. the ocean is becoming more salty.
B. the earth is slowly cooling off.
C. radioactive changes are taking place.
D. glaciers on earth are melting.
E. the total thickness of all the sedimentary layers of the earth can be estimated.

99. Which of the following statements concerning the origin
(1.20) of man is generally accepted by scientists?

A. There is a force responsible for the creation of life which is clearly understood by science.
B. Human life was created in a supernatural and mysterious manner.
C. There is a direct chain of development in organic life, with man descending from the anthropoid apes.
D. The Biblical conception of creation is entirely lacking in scientific truth.
E. Man has developed by stages through the processes of mutation and adaptation.

100. One would be *least* likely to find any fossils in
(1.20)

A. sandstone. **B.** limestone. **C.** granite.
D. shale. **E.** bituminous coal.

101. The wings of an eagle and the arms of a man are
(1.20)

A. biramous. **B.** analogous. **C.** homologous.
D. dichotomous. **E.** homozygous.

102. Adaptations separating the vertebrates from the inverte-
(1.20) brates include all of these *except*

A. an internal supporting skeleton composed of cartilage or calcified tissues.
B. fin-like appendages for swimming leverage.
C. arrangement of body parts in a wheel-like symmetrical pattern.
D. development of jaws from a transverse mouth.
E. segmented body muscles permitting lateral bending of the body.

103. In comparing the fossil record of the history of plants,
(1.20) with the fossil record of the history of animals it can be said that

A. plants have left the more complete record.
B. animals have left the more complete record.
C. there are more "missing links" in the animal chain.
D. the plant and animal records can be interpreted with equal ease.
E. the animal record has the earlier beginning.

104. Of the following the best criterion for determining how
(1.20) far advanced along the evolutionary scale a plant may be is

A. whether the plant chooses a land rather than a predominantly water environment.
B. the size attained by a mature plant of the species.
C. whether the fruit contains few or many seeds.
D. the degree of adaptation to a specific environment.
E. the number and form of stamens, pistils, and petals.

105. Of these examples the plant group that has evolved
(1.20) the farthest from primitive form is

A. seed ferns. **B.** thallophytes. **C.** club mosses.
D. conifers. **E.** leafy ferns.

106. Which of the following statements does *not* apply to
(1.20) both an elm tree and a cat?

A. It carries on the process of digestion.
B. It carries on the process of reproduction.
C. It carries on the process of transportation.
D. It is made up of organs.
E. It can make organic food substances out of inorganic materials.

107. All human beings living on the earth today are regarded
(1.20) as belonging to one species because

A. this makes for simplicity in classification.
B. they are anatomically similar in structure.
C. they are classified as *Homo sapiens.*
D. all primates possess flexible fingers.
E. the entire population of the earth descended from Adam and Eve.

For items 108 - 115, select from the key the most appropriate phrase.

KEY

A. Amphibians. **B.** Fish. **C.** Mammals.
D. Shellfish. **E.** Reptiles.

108. Appeared first in evolutionary development.
(1.20)

109. Developed from the amphibians.
(1.20)

110. Appeared last in evolutionary development.
(1.20)

111. Gave rise to the mammals.
(1.20)

112. Evolved from the fish.
(1.20)

113. Gave rise to the reptiles.
(1.20)

114. First lived on the land.
(1.20)

115. Gave rise to the amphibians.
(1.20)

116. Man is at the apex of the evolutionary scale primarily
(1.20) because he has

A. the longest life span of all living organisms on the earth.
B. more cells in his body than any other living thing.
C. more appendages than any other organism.
D. lived longer on the earth than any other animal or plant.
E. the most complex nervous system of all the living organisms found on the earth.

117. The emergence of aquatic animal life to the land habitat
(1.20) is perhaps best illustrated by which of the following groups of animals?

A. Sponges and corals. **B.** Mammals
C. Reptiles. **D.** Fish. **E.** Amphibians.

118. An evolved (and probably evolving) genetically dis-
(1.20) tinctive, reproductively isolated natural population represents

A. a natural group of plants and animals.
B. a race of man. **C.** varieties in plants.
D. the species concept. **E.** the organismal concept.

119. In man all *except* which one of the following are vestig-
(1.20) ial structures?

A. The vermiform appendix.
B. Muscles for moving the outer ear.
C. Hair on the body. **D.** The coccyx.
E. The urinary bladder.

120. Some animals provide no care for their young. Such
(1.20) species nevertheless survive, primarily because they

A. are usually prolific.
B. are usually protectively colored. **C.** lay eggs.
D. are aquatic animals.
E. are herbivorous animals and their food is plentiful.

121. The statement that "all men are created equal" is
(1.20)

A. biologically sound. **B.** true.
C. evidence of evolution.
D. a psychological principle. **E.** biologically untrue.

122. Darwin concluded that
(1.20)

A. *only* those forms which are *best* suited for a *given* environment survive.
B. Many structures are found in plants and animals which cannot be shown to have survival value.
C. In evolution, cooperation is more important than competition.
D. "Natural selection" explains the causes of variation.
E. Those variants which are better adapted to an environment will reproduce in greater numbers.

123. The only positive evidence of evolution is that pro-
(1.20) vided by

A. physiology. **B.** geology. **C.** genetics.
D. hygiene. **E.** embryology.

124. Which one of the following statements concerning the
(1.20) origin of man is generally accepted by scientists?

A. There is a direct line of development in organic life, with man descending from the anthropoid apes.
B. Man has developed by stages through processes of mutation and adaptation.
C. The Biblical conception of the origin of man is altogether illogical.
D. There is a force, responsible for the origin of life, which is clearly understood by scientists.
E. There is no explanation, which is either plausible or logical, that will account for the origin or development of man.

125. It is believed that man has been successful in attain-
(1.20) ing his position in the animal kingdom as a result of a combination of factors. Which of the following is not considered to be one of the contributing factors?

A. His thumb is opposable to the other digits.
B. Development of his sense of smell.
C. His well-developed cerebrum.
D. His developed organs of speech.
E. His terrestrial habitat (man lives on the ground rather than underground, in trees, in the air, or in water).

126. The fact that certain plants produce edible fruits has
(1.20) evolutionary significance for the plants because

A. the food stored in the fruit is used by the seeds for growth.
B. these fruits enable many animals to survive.
C. the seeds are dispersed in the animals' feces.
D. most plants store food in the fruits for their own future use.
E. of none of the above.

127. Of the following which one of these animal forms
(1.20) appeared earliest upon the earth?

A. Fox. **B.** Starfish. **C.** Snake. **D.** Shark.
E. Bat.

128. Of the following which one of these plant forms ap-
(1.20) peared earliest upon the earth?

A. Clover. **B.** Maple. **C.** Fern. **D.** Hemlock.
E. Rose.

129. All except which one of the following are vestigial
(1.20) structures in man?

A. The vermiform appendix.
B. The muscles for moving the outer ear.
C. The gall bladder. **D.** Hair on body.
E. The coccyx.

130. The earth is estimated conservatively to be one and
(1.20) one-half to three and one-half billion years old. One estimate places the first life on earth one billion years ago. It is commonly believed by biological scientists that

A. life has existed on the earth continuously since that time.

B. life died out completely at the end of each geologic era to originate again in the following era.
C. life died out at the end of each major glacial period previous to the recent Pleistocene glaciation.
D. life died out completely only during the last glacial period when northern North America and the United States were covered in places with ice 10,000 feet thick.
E. there are several breaks in the geologic fossil record contemporaneous with times of severe volcanic activity which indicate with some certainty that life completely disappeared during those periods.

131. It appears that the history of living things is one of
(1.20)

A. fixed, immutable types.
B. continual recombinations of the same simple units.
C. continual diversification and adaptation.
D. change, independent of any external influence.

132. One of the concepts in Darwin's theory of natural selec-
(1.20) tion is that those species survive which are the

A. most ruthless.
B. best fitted to their general environment.
C. most intelligent.
D. most highly specialized, particularly in food requirements.

For items 133 - 138 select from the key the number of years which most closely approximate the length of time which the animals of the class mentioned in the item have lived on the earth, then mark the corresponding answer space.

KEY

A. 1 million years. **B.** 60 million years.
C. 200 million years. **D.** 290 million years.
E. 300 million years.

133. The class to which the alligator belongs.
(1.20)

134. The class to which the squirrel belongs.
(1.20)

135. The class to which the frog belongs.
(1.20)

136. The class to which the codfish belongs.
(1.20)

137. *Homo sapiens.*
(1.20)

138. The class to which the modern birds belong.
(1.20)

139. Ancient man appeared on earth
(1.20)

A. immediately before the dinosaurs died out.
B. at a time immediately after the dinosaurs disappeared.
C. in the late Cenozoic.
D. immediately after the amphibians were the dominant forms.
E. in the late Paleozoic.

140. In geologic time the
(1.20)

A. Cenozoic was an earlier period than the Mesozoic.
B. Proterozoic was an earlier period than the Archeozoic.
C. Paleozoic immediately preceded the Proterozoic.
D. Mesozoic immediately followed the Proterozoic.
E. Cenozoic immediately followed the Mesozoic.

141. It is believed that earliest-known man lived during the
(1.20)

A. Eocene. **B.** Miocene.
C. latter part of the Oligocene and subsequent epochs.
D. early part of the Pleistocene. **E.** none of these.

142. Darwin believed that
(1.20)

A. evolution takes place by the action of mutations.
B. man descended from the present-day apes.
C. evolution comes about through survival of the fittest.
D. the doctrine of fixity of species was valid.
E. individuals of a given species vary little, if at all, in individual traits.

For items 143 - 149 select the most appropriate term from the key list below:

KEY

A. Symbiosis. **B.** Positive phototropism.
C. Liebig's Law of the Minimum. **D.** Succession.
E. Biotic potential.

143. Most clearly involved in a moth's flying into a candle
(3.00) flame.

144. Depends upon the number of young produced by each
(1.20) female.

145. Depends upon the number of generations per unit of
(1.20) time.

146. Depends upon the number of females per male.
(1.20)

147. Interspecific cooperation.
(1.20)

148. Theoretically calculable by multiplying "existing popu-
(1.20) lation" by "environmental resistance."

149. Relationship between constituents of a lichen.
(1.20)

150. Variation among individuals of a species is of no sig-
(1.20) nificance in evolution if it is caused by

A. environmental factors.
B. mutations of single genes only.
C. losses or gains of whole chromosomes.
D. loss (or gain) of parts of chromosomes.
E. new gene combinations resulting from crossovers.

151. From a consideration of the habitat and life cycle of
(1.20) the tapeworm one would expect the adult worm to have

A. a well-developed reproductive system.
B. well-developed organs of sense.
C. functional organs for locomotion.
D. a normally developed digestive system.
E. glands secreting ptyalin.

Items 152 - 164. Refer to the table below, and for each of the following questions select the letter of the correct geological time period.

Cenozoic	Quaternary	A
	Tertiary	B
Mesozoic	Cretaceous	C
	Jurassic	D
	Triassic	E
Paleozoic	Permian	F
	Carboniferous	G
	Devonian	H
	Silurian	I
	Ordovician	J
	Cambrian	K

152. Marine invertebrates, no land life known.
(1.20)

A. A. **B.** K. **C.** D. **D.** F. **E.** H.

153. First known land plants.
(1.20)

A. G. **B.** J. **C.** B. **D.** C. **E.** I.

154. First known anthropoids.
(1.20)

A. C. **B.** F. **C.** J. **D.** B. **E.** K.

155. First birds.
(1.20)

A D. **B.** E. **C.** A. **D.** H. **E.** I.

156. First non-placental mammals.
(1.20)

A. K. **B.** E. **C.** F. **D.** C. **E.** B.

157. First cycads, ginkgoes, and conifers.
(1.20)

A. I. **B.** A. **C.** G. **D.** E. **E.** J.

158. First ostracoderm fishes.
(1.20)

A. J. **B.** C. **C.** B. **D.** F. **E.** G.

159. First amphibians.
(1.20)

A. A. **B.** G. **C.** H. **D.** C. **E.** D.

160. Great coal-forming forests.
(1.20)

A. G. **B.** D. **C.** I. **D.** B. **E.** A.

161. Age of man.
(1.20)

A. C. **B.** E. **C.** G. **D.** F. **E.** A.

162. First modern insects, climax of horsetails.
(1.20)

A. H. **B.** F. **C.** I. **D.** C. **E.** D.

163. First placental mammals.
(1.20)

A. C. **B.** D. **C.** K. **D.** J. **E.** F.

164. First reptiles.
(1.20)

A. F. **B.** H. **C.** E. **D.** G. **E.** I.

165. Xerophytes (sagebrush and other desert plants) have
(120) become adapted to their arid habitat by

A. developing broad leaves to reduce transpiration.
B. developing leaves much reduced in size with recessed stomata.
C. modification of their leaves to enable the plants to absorb moisture from the atmosphere instead of from the soil.
D. modification of the colloidal composition of their protoplasm to eliminate the need for water.
E. none of the above means.

166. Concerning the origin of life on the earth, it is believed
(1.20) by most scientists that

A. the manner in which life came into being on the earth will forever remain inexplicable.
B. life originated on the earth by special creation.
C. life was transferred to the earth from outer space in the form of minute living germ particles which originated from existing life on some other celestial body.
D. the first living matter slowly arose from non-living matter as soon as conditions upon our planet became conducive to the support of life.
E. life was on the earth at the time the earth was formed.

167. The lack of broad leaves on the cactus and the adapta-
(1.20) tion of the stem to food-making are characteristics which

A. increase transpiration. **B.** conserve water.
C. afford protection against cattle.
D. are quickly lost when the plant is placed in a different environment.
E. are commonly found in regions of heavy rainfall.

168. A large majority of the species of one of the following
(1.20) groups were dependent upon the prior development of the insects. That group is

A. fish. **B.** flowering plants. **C.** ferns.
D. mammals. **E.** molluscs.

169. Which one of the following is *not* a member of our
(1.20) solar system?

A. Pluto. **B.** Uranus. **C.** Polaris. **D.** Jupiter.
E. Neptune.

Items 170 - 176. The table below lists the main ancient groups of fishes. For each of the following statements, give the letter of the fish type to which it refers.

Ostracoderms	A
Cartilaginous fishes	B
Placoderms	C
Ray-finned fishes	D
Lungfishes (Dipnoi)	E
Lobe fins (crossopterygians)	F

170. A group which arose from primitive bony fishes, had
(1.20) lungs, and has three genera alive today, though they have not given rise to any further groups.

A. B. **B.** C. **C.** D. **D.** E. **E.** F.

171. A group which arose directly from the ostracoderms,
(1.20) had primitive jaws, and was extinct by the end of the Devonian.

A. B. **B.** C. **C.** D. **D.** E. **E.** F.

172. (1.20) A group which includes almost all of our present-day fishes.

A. B. **B.** C. **C.** D. **D.** E. **E.** F.

173. (1.20) A group which gave rise to the amphibians.

A. B. **B.** C. **C.** D. **D.** E. **E.** F.

174. (1.20) The most primitive group to have arisen from the ostracoderms.

A. B. **B.** C. **C.** D. **D.** E. **E.** F.

175. (1.20) A group in which the lung has changed to an air bladder.

A. B. **B.** C. **C.** D. **D.** E. **E.** F.

176. (1.20) A group which has representatives today that pass seasons buried in mud in a cocoon of slime.

A. B. **B.** C. **C.** D. **D.** E. **E.** F.

Items 177 - 181. Select the most appropriate answer to each of these items from the following key:

KEY

A. fish **B.** bird. **C.** starfish. **D.** amphibian
E. reptile

177. (1.20) Which sequence gives the three most ancient animals, of those named in the key list, in order of their first appearance on the earth?

A. A B C. **B.** C A D. **C.** A D E.
D. C D E. **E.** B E A.

178. (1.20) Which sequence of the animals named in the key list gives the three most recent animals in order of their first appearance on the earth?

A. A B C. **B.** B C D. **C.** A C E.
D. D E B. **E.** C D E.

179. (1.20) To which type of animal given in the key list are birds most closely related?

A. A. **B.** B. **C.** C. **D.** D. **E.** E.

180. (1.20) From which type of animal given in the key list did reptiles arise?

A. A. **B.** B. **C.** C. **D.** D. **E.** E.

181. (1.20) From which type of animal given in the key list did amphibians arise?

A. A. **B.** B. **C.** C. **D.** D. **E.** E.

Items 182 - 191. Answer each of the following questions by use of the key below:

KEY

A. Special creation **B.** Struggle for existence
C. Natural selection **D.** Catastrophism
E. Uniformitarianism

182. (1.10) Which of the above concepts was first suggested by James Hutton in 1795?

A. A. **B.** B. **C.** C. **D.** D. **E.** E.

183. (1.20) Which of the above concepts were embodied in the Darwinian theory of evolution?

A. A and B. **B.** A and C. **C.** B, C, and E.
D. A, D, and E. **E.** B and D.

184. (1.20) Which of the above was suggested by the clergy as an explanation for the widespread occurrence of fossilized extinct types of animals?

A. A. **B.** B. **C.** C. **D.** D. **E.** E.

185. (1.20) Which of the above holds that species living today have all existed since the beginning without change?

A. A. **B.** B. **C.** C. **D.** D **E.** E.

186. (1.20) Which of the above are integral parts of the modern evolution theory?

A. A and D. **B.** B and D. **C.** A and [illegible]
D. C and E. **E.** C and D.

187. (1.20) Which of the above is one of the basic concepts in modern geology?

A. A. **B.** B. **C.** C. **D.** D. **E.** E.

188. (3.00) Which of the above might play a vital part in accomplishing the end result described in the following statement? "A great deal of evolution is mere diversification, yet there can be perceived a series of long-range trends. The great majority of these trends are specializations which fit the existing type more closely to one mode of life, and in so doing cut it off from success in others."

A. A and D. **B.** B and D. **C.** B and C.
D. A and B. **E.** C and D.

189. (1.10) Which of the above led to a recognition of the extremely great age of the earth?

A. A. **B.** B. **C.** C. **D.** D. **E.** E.

190. (1.20) Which of the above are antagonistic to the principle of evolution?

A. A and E. **B.** A and C. **C.** B and D.
D. A and D. **E.** C and D.

191. (1.10) Which of the above was the prevailing belief for many centuries?

A. A. **B.** B. **C.** C. **D.** D. **E.** E.

Items 192 - 194. From the key list, select the term best illustrated by each statement.

KEY

A. homology **B.** analogy **C.** metamorphosis
D. adaptive radiation **E.** adaptive convergence

192. (1.20) Many insects have immature stages which differ widely from the adult in appearance, habits, and structure. A special stage, the pupa, occurs in their life cycle to accomplish the transformation from larva to adult.

193. (1.20) The framework of the wings is basically similar in both birds and bats, and the wings of both have a similar origin in the embryo.

194. (1.20) The three pairs of legs of insects are homologous throughout the insect group, and each pair is serially homologous with the other two, but any pair may be modified for the specialized functions. Forelegs transformed into organs for seizing prey are common; the hind legs of grasshoppers and crickets are formed for jumping, while those of the giant water bugs are flattened and fringed with long stiff hairs which make them effective swimming organs.

For items 195 - 204 select from the key the scientist most closely related to the description.

KEY

A. Darwin B. Mendel C. Lamarck D. Pasteur
E. Jenner

195 (1.20) Developed the first complete and logical theory of evolution, the mechanics of which he based largely upon two laws, the second law stating that acquired characteristics may be inherited.

196. (1.20) Said, "As many more individuals of each species are born than can possibly survive, and as, consequently, there is frequently recurring struggle for existence, it follows that any being, if it vary however slightly in any manner profitable to itself, under the complex and sometimes varying conditions of life, will have a better chance of surviving, and thus be naturally selected. From the strong principle of inheritance any selected variety will tend to propagate its new and modified form."

197. (1.20) Developed a successful treatment for rabies.

198. (1.20) Developed vaccination for smallpox.

199. (1.20) Was the first to gain an insight into the systematic manner in which characteristics are inherited.

200. (1.20) Contributed greatly toward discrediting the idea of spontaneous generation.

201. (1.20) Gathered a great amount of factual material to support the idea of evolution while on a voyage in H.M.S. *Beagle.*

202. (1.20) Was an Austrian monk.

203. (1.20) Was an English country doctor.

204. (1.20) In the year 1838 read Malthus's "Essay on Population" in which Malthus showed how populations increased in geometric ratio until checked by limiting factors; and from this essay, based certain of his fundamental ideas.

205. (1.20) The statement "Ontogeny repeats phylogeny" means that

- **A.** the animals of the past were as variable as those existing today.
- **B.** structures used for the same purpose have similar embryonic origin.
- **C.** individual development presents an abridged history of the stages through which the race passed in its evolution.
- **D.** the evolutionary capabilities of a species depend largely upon its reproductive capacity.
- **E.** all embryos look alike.

206. (1.20) Which part of man's skeleton has increased most markedly over the same structure in the skeleton of an ape?

- **A.** The relative cranial capacity.
- **B.** The number of digits.
- **C.** The relative length of the arm.
- **D.** The number of teeth. **E.** None of the above.

207. (1.20) Changes in climate and topography are thought to have effect upon the evolution of organisms when

- **A.** the climatic changes cause genes to mutate.
- **B.** the organisms adapt themselves to the changes and these adaptations are inherited.
- **C.** mutations result in organisms better adapted to these changes.
- **D.** they cause death of all existing organisms and spontaneous generations of new ones.

208. (1.20) During the era when the coal-forming plants predominated there were in existance

- **A.** very few varieties of animals.
- **B.** just insects and chordates. **C.** all phyla of animals.
- **D.** mainly protozoans and sponges.
- **E.** predominantly man and apes.

209. (1.20) New fossil species will not be found in the future. This statement is

- **A.** probably true because nearly all parts of the earth have been reached by archaeologists.
- **B.** probably false because many forms undoubtedly lie in rock layers beneath the ocean, and though unavailable now may be available in the future.
- **C.** probably true because all changes in the earth's surface have now taken place and therefore no new forms will develop.
- **D.** probably true because, though some parts of the earth's surface are unexplored, development there would be along the same lines as in other places which have been investigated.

210. (1.20) Based on fossil record it is true that

- **A.** man arose from the ape.
- **B.** man and ape arose from one species.
- **C.** the ape arose from an early form of man.
- **D.** man arose from a form produced by the ape.
- **E.** none of the above are known to be fact.

211. (1.20) In studying fossil forms of man and other animals

- **A.** we cannot reconstruct the form unless we have the complete skeleton of one of the species.
- **B.** we cannot reconstruct the form unless we have all parts of the skeleton, though parts may be from different individuals.
- **C.** the skeleton alone is insufficient to give much information on the species.
- **D.** a few skeletal fragments give us much information about the form.

212. (1.20) The origin of man from ape is considered by scientists at present to be improbable. One reason for this is

- **A.** man has no tail.
- **B.** apes are concentrated in the Old World.
- **C.** there are several species of apes existing now, but only one species of man.
- **D.** very early fossil forms of man have a much greater cranial capacity than that of present-day apes.

213. (1.20) The fossil forms of man which have been found are

- **A.** all in the same family but belong to different genera and species.
- **B.** all in the same family, genus and species.
- **C.** all in the same family and genus but different species.
- **D.** in several different families but the same order.
- **E.** in the same phylum, but are unrelated beyond that.

214. (1.20) Which of the following would result in something probably *not* considered a fossil?

- **A.** The remains of a now extinct animal frozen in the ice in Northern Europe.

B. The bones of a dog dug up in a prairie after having been buried there for a year.
C. The print of a fern found in a rock taken from a coal mine.
D. A piece of amber containing a complete insect.
E. A stone fish whose structures have been replaced by minerals, and the original form maintained.

215. (1.20) One of the limitations of the radio-carbon method when used for the determination of the age of fossils is that it would not be

A. present in tree fossils.
B. detected with present-day instruments in fossils over 20,000 years old.
C. present in bones.
D. found in the same quantity in fossils of the same age from China and North America.
E. found in organic fossils.

216. (1.20) The wings of a butterfly and the wings of a bird are examples of characters that are

A. homologous. **B.** analogous.
C. radially symmetrical. **D.** mutations.
E. discontinuous variations.

217. (1.10) An elastic rod running lengthwise in the body above the alimentary canal found in chordates is called a

A. backbone. **B.** vertebra. **C.** notochord.
D. spinal cord. **E.** spinal column.

218. (1.20) Body structures which are fundamentally alike and develop in the same way are said to be

A. analogous. **B.** homologous. **C.** homogeneous.
D. heterogeneous. **E.** embryological.

219. (1.10) Any actual remains, molds, casts, or tracks left by a plant or animal of past geologic times is called a (an)

A. geological object. **B.** archeological object.
C. proof of evolution. **D.** fossil. **E.** petrification.

220. (1.20) Direct evidence of evolutionary change in the life of the past is offered by

A. domestication. **B.** experimental breeding.
C. isolation. **D.** the fossil record.
E. natural selection.

221. (1.20) The brain structure which has undergone greatest evolutionary change from the lowest to the highest vertebrates is the

A. cerebellum. **B.** medulla oblongata.
C. cerebrum. **D.** brain stem. **E.** thalamus.

222. (1.20) Structural similarities between two animals of different species is probably due to the fact that

A. these two species of animals lived in the same environment.
B. they are genetically related to a common ancestor.
C. those characteristics which are alike perform the same function.
D. these two species have passed through a period of adaptation.
E. it just happened or is due to chance.

223. (1.20) Which aspect of the horse has undergone a very radical evolutionary change from antiquity to the present time?

A. The relative length of its neck has greatly increased.
B. The horse has evolved from a tailless to a tailed animal.
C. The horse has acquired a more uniform body size and type.
D. The number of functional toes has decreased.
E. The horse has changed from a carnivorous to a herbivorous animal.

224. (1.20) Which one of the following might best be called a guiding factor in organic evolution?

A. Mutations. **B.** Natural selection.
C. Recombination. **D.** Crossing over.
E. Linkage.

225. (1.20) Which of the following type organisms seems to have the greatest possibility of survival as the environment changes?

A. The organism that is highly developed and specialized.
B. The organism that is adaptable and usually small in size.
C. The organism that is dependent upon one other species for its food.
D. Two of the above. **E.** None of the above.

226. (1.20) Knowing that environments vary over long periods of time, what must happen within populations of organisms if such populations are to survive?

A. New species must be created.
B. The reproductive rate must increase.
C. Genera of such populations must cross breed with genera of another population.
D. The biotic potential must increase many times.
E. Suitable mutations must occur and be perpetuated.

227. (1.20) Which one of the following is the most recent era or division of the earth's history?

A. Proterozoic. **B.** Archeozoic. **C.** Paleozoic.
D. Cenozoic. **E.** Mesozoic.

228. (1.20) An estimate of the age of the earth can be made most accurately from studies based upon

A. the rate of deposition of sedimentary rocks.
B. chemical analysis for uranium and lead in igneous rock.
C. the rate of erosion of the continents.
D. the total salt content of the oceans.
E. the tidal effect of the moon.

229. (1.20) Which of the following sources of information sheds most light on the geological history of the earth in past ages?

A. Observation of sun spots.
B. The study of genetics.
C. Observation of ecological interrelationships among organisms.
D. Taxonomic study of the earth's living animals and plants.
E. The study of fossils.

230. (1.20) A tree-dwelling animal would likely find which one of the following adaptations most advantageous to living in trees?

A. Sharp teeth. **B.** Large hind legs.
C. Short front legs. **D.** A prehensile tail.
E. A long neck.

231. (1.20) Whether or not a species can be permanently land-dwelling is most dependent upon a factor associated with its mode of

A. locomotion. **B.** reproduction.
C. reaction to stimuli. **D.** excretion.
E. obtaining food.

232. (1.20) Which of the following evolutionary changes most probably preceded all the others?

A. From an organism reproducing by gametes produced by one individual to an organism reproducing by gametes from two individuals.
B. From an organism reproducing by simple cell division to one reproducing by spores.
C. From a free-living organism to a parasitic organism.
D. From a one-celled body with no apparent structures to one with specialized structures.
E. From a non-motile organism to one capable of moving about.

233. (1.20) Which of the following factors has, apparently, been *least* effective in bringing about evolution?

A. Environmental factors such as temperature, drought, famine, etc.
B. The use or disuse of plant or animal organs.
C. The number of offspring produced by a species.
D. Geographical redistribution of plants or animals.
E. Natural selection.

234. (1.20) Organic evolution is now considered by biological scientists

A. a somewhat inadequately substantiated theory.
B. a well-substantiated hypothesis but not a theory.
C. a generally accepted theory, as is also the manner in which evolution takes place.
D. a generally accepted principle, although the manner in which it comes about is in debate.
E. not acceptable, since no well-substantiated theory of the manner in which it comes about has as yet been developed.

235. (1.20) It is believed by most recognized scientists that

A. in the stream of life all forms have become increasingly complex.
B. the breaks in the fossil record (times when fossils were not preserved) correspond to breaks in the stream of life when there was no life on the earth.
C. the stream of life since earliest time has been broken several times, to originate again after each break by the creation of forms higher in the evolutionary scale than those in existence before the break.
D. the stream of life since earliest time has been broken several times, to originate again after each break from a more primitive form.
E. life has been in existence continuously on the earth without a break since the time of its origin some millions of years ago.

236. (1.20) There are two different fossil forms, each representing different phyla, found in the undisturbed rock layers of a cliff. One of these is the early amphibian, ***Onychopus.*** It is found in a rock layer near the top of the cliff. The other form found in the rock layers below the amphibian is

A. a dinosaur. **B.** a primitive dog.
C. the primitive bird, Archeopteryx.
D. a snake. **E.** a fish.

237. (1.20) The animal form following in evolution the amphibian is the

A. reptile. **B.** fish. **C.** bird. **D.** mammal.
E. shellfish.

238. (1.20) From the standpoint of our conception of evolutionary complexity, which one of the following plants occupies the same position in relation to the other four as mankind occupies in relation to all the other species of animals, living and extinct?

A. Dandelion. **B.** Pine. **C.** Modern fern.
D. Moss. **E.** Seed fern.

239. (1.20) The theory of special creation differs from the theory of organic evolution by maintaining that

A. exactly the same kinds of animals and plants now exist on the earth as when life first began on the earth.
B. life emerged from the simple to the complex by an unfolding process which extended over many millions of years.
C. in antiquity non-living matter was transformed into a very primitive form of life from which all present-day living things have arisen.
D. some unknown force within the organism guides the mutations which occur and which are transmitted in heredity to succeeding generations.
E. as a consequence of overproduction in every species a struggle ensues in which only the best in each species survive to produce the next generation.

240. (1.20) From the standpoint of science, the chief significance of vestigial structures is that they

A. indicate a high degree of specialization.
B. occur most commonly in embryos.
C. are very abundant in fossil forms indicating that modern animals and plants are more highly evolved.
D. were once functional and indicate change in structure and function.
E. constitute the chief basis for classification of animals beyond the phylum category.

Item 241 deleted.

242. (1.20) The similarity between two or more species of a genus is due to

A. food.
B. climatic conditions.
C. origin.
D. reproduction.
E. the total environment.

243. (1.20) Of these examples the plant group that has evolved the most from primitive form is

A. seed ferns.
B. thallophytes.
C. club mosses.
D. conifers.
E. leafy ferns.

244. (1.20) The earliest evolutionary advance beyond the single-celled protozoa probably was the

A. arrangement of cells in layers.
B. segmentation of body parts.

C. differentiation of certain cells for division of labor.
D. aggregating cells of the same type.
E. addition of an external limy skeleton.

245. (1.20) In comparing the fossil record of the history of plants with the fossil record of the history of animals it can be said that

A. plants have left the more complete record.
B. animals have left the more complete record.
C. there are more "missing links" in the animal chain.
D. the plant and animal records can be interpreted with equal ease.
E. the animal record has the earlier beginning.

246. (1.20) Of the following the best criterion for determining how far advanced along the evolutionary scale a plant may be is

A. whether the plant chooses a land rather than a predominantly water environment.
B. the size attained by a mature plant of the species.
C. whether the fruit contains few or many seeds.
D. the degree of adaptation to a specific environment.
E. the number and form of stamens, pistils, and petals.

247. (1.20) When we consider the problem of plant and animal evolution and the problems of modern plant and animal life, the greatest evolutionary step probably was the

A. specialization of the protoplasm so as to free it from a water environment.
B. differentiation of the protoplasm into cellular form.
C. development of nerve tissue.
D. differentiation of the endoderm, mesoderm, and ectoderm.
E. development of the ability to use the energy of the sun.

248. (1.20) If all species of animals were to successfully mate with each other the most logical outcome would be

A. the development of many new and widely diverse species.
B. the elimination of a few present species.
C. the development of a single species.
D. the destruction of all animal life.
E. an increased rate of environmental adaptation.

249. (1.20) That children can be expected to pass through the "little savage" stage is a cultural extension of the biological theory of

A. survival of the fittest.
B. inheritance of acquired adaptative structures.
C. recapitulation. D. segregation.
E. negative commensalism.

250. (1.20) A large majority of the species of one of the following groups were dependent upon the prior development of the insects. That group is

A. fish. B. flowering plants. C. ferns.
D. mammals. E. mollusks.

251. (1.20) Which of the following sources of information sheds most light on the geological history of the earth in past ages?

A. Observation of sun spots.
B. The study of genetics.
C. Observation of ecological interrelationships among organisms.
D. Taxonomic study of the earth's living animals and plants.
E. The study of fossils.

252. (1.20) Which of the following is evidence that tends to refute the Lamarckian theory of organic evolution?

A. Fish that live in caves are usually blind.
B. The great anteater has no functional teeth.
C. The human being possesses a vermiform appendix.
D. The mole has minute, almost invisible eyes.
E. The giraffe has a long neck and long front legs.

Items 253 - 258 are concerned with various evidences for biological evolution. Select from the key the category of evidence to which the item refers and mark the corresponding answer space.

KEY

A. Paleontology. B. Embryology.
C. Comparative physiology. D. Vestigial organs.
E. Comparative anatomy.

253. (1.20) Though man doesn't normally use them, there are muscles in his head for moving his outer ears.

254. (1.20) There is pronounced uniformity in the skeletons of various vertebrates including a mammal, a bird, a reptile, and an amphibian.

255. (1.20) The so-called higher animals pass through stages in their development which, in a general way, represent conditions that are fully brought out in adults of animals lower in the scale.

256. (1.20) Chemical tests have been developed by means of which similarities of the blood of related animals can be demonstrated.

257. (1.20) In the Grand Canyon the imprints and mineralized replacements of original organisms are arranged so that the oldest lie at the bottom and the youngest or last formed lie at the top.

258. (1.20) Certain hormones derived from endocrine glands show like reactions when injected into widely different animals.

259. (1.20) Evidence for organic evolution derived mainly from a study of physiology includes which of the following?

A. Fossils. B. Visceral arches.
C. Vestigial organs. D. Blood relationships.

260. (1.20) Which of the following represents man's chief progress over the ape?

A. Permanently erect posture.
B. Better developed sense organs.
C. Larger brain capacity.
D. Freedom of arms from locomotor function.

261. (1.20) Which one of the following is not homologous with the others?

A. The wing of an insect. B. The wing of a bird.
C. The wing of a bat. D. The flipper of a whale

262. (1.20) An animal phylum undergoing adaptive radiation is probably *not*

A. becoming more diversified.
B. continuing to occupy well-established environmental situations.
C. establishing a new major body plan.
D. modifying an established body plan.
E. occupying new environments.

There are five digits (fingers or toes) on each limb of man, numbered beginning with the thumb (or great toe).

Responses for items 263 - 267

A. first and fifth. **B.** second and fourth.
C. third. **D.** first and third. **E.** second and third.

263. (1.20) Which completely disappears in both horse and camel?

264. (1.20) Which persists as functional parts in the horse?

265. (1.20) Which persist as splints in the horse?

266. (1.20) Which persist in the camel?

267. Which persists in both horse and camel as useful parts?

268. (1.20) Which of the following adaptations to life on land did the primitive amphibians develop most highly?

A. running on land. **B.** reproduction out of water.
C. resistance to drying in air.
D. complete separation of two blood streams in heart.
E. lung breathing.

269. (1.20) Diversity or variation in the plant kingdom is enhanced by

A. self-pollination. **B.** cross-pollination.
C. vegetative reproduction. **D.** double fertilization.
E. spore reproduction.

270. (1.20) The power of regeneration in radially symmetrical animals is

A. greater than **B.** less than
C. same as the power of regeneration in bilaterally symmetrical animals.

271. (1.20) Weismann concludes that "nuclear matter cannot have the same constitution everywhere in the organism," i.e., the nuclei of different tissues are different. This conclusion *necessarily* follows from Weismann's belief that

A. the nucleus is the sole bearer of heredity.
B. fertilization depends on the union of the egg nucleus with the sperm nucleus.
C. the nucleus exerts a control over the growth and assimilative activities of the cytoplasm.
D. one-celled animals are incapable of regeneration or cell division without a nucleus.
E. the nucleus is the sole determiner of the nature of the cell.

272. (1.10) The authors who explicitly take issue with Weismann's conclusion, Spemann, Spiegelman, and Waddington, do not accept Weismann's premise. Instead, all three men hold that

A. a zygote without a nucleus may develop into an embryo.
B. the characteristics of a cell are a function of a number of factors, including the physico-chemical environment of the cell.
C. the mitotic division divides the nucleus into two equal-appearing sets of chromosomes.
D. there are cytoplasmic genes which are independently self-duplicating and are therefore bearers of heredity.
E. the cytoplasm determines the nature of the nucleus.

273. (1.10) Weismann hypothesizes that the mechanism for the differentiation of nuclei is inherent in the process of

A. mitosis. **B.** meiosis. **C.** mutation.
D. metabolism. **E.** fertilization.

274. (1.20) Spemann's experiments on the delayed nucleation of half-embryos make Weismann's hypothesis untenable, since Spemann proves that

A. the cytoplasm is divided unequally in every cell division.
B. the nuclei of all cells are the same.
C. the cytoplasm determines the nature of the nucleus.
D. a complete zygote nucleus, i.e., one containing a complete set of maternal and paternal chromosomes, is not necessary for development.
E. any one nucleus in a several-celled embryo has the same potentialities as the zygote nucleus.

275. (1.20) The greatest detail in description would be necessary to identify

A. a phylum as distinct from all other phyla.
B. an order as distinct from all other orders.
C. a genus as distinct from all other genera.
D. a class as distinct from all other classes.
E. a species as distinct from all other species.

276. (1.20) The system of classification of organisms used by Linnaeus and Darwin is one in which

A. groups are composed of smaller groups which in turn are composed of still smaller groups, and so on.
B. the modes of adapting to environmental conditions and the types of environmental conditions are the most important bases for the classification.
C. the same organism has several designations, depending on the criterion used for classifying.
D. a single characteristic used for classifying all organisms leads to a unique pigeonhole for each organism.
E. common biochemical processes indicate the relationships of all organisms.

277. (1.20) The taxonomic (classificatory) grouping which usually encompasses the smaller number of individuals is

A. the genus. **B.** the variety. **C.** the order.
D. the species. **E.** the class.

278. (1.20) Both Linnaeus and Darwin consider the characters most serviceable for classifying to be those which

A. are found in the embryo but not in the adult.
B. are least influenced by alterations in the environment.
C. concern the shape of the leaf.
D. display the greatest degree of variation.
E. are invariable for all living organisms.

279. (1.20) All genera

A. are in the same family.
B. include one or more species each.
C. include the same number of species apiece.
D. are completely arbitrary groupings of species and varieties.
E. can be distinguished from each other by itemizing the class and order to which each belongs.

280. Linnaeus states that nomenclature and classification proceed together, each indispensable to the other. This rests upon the premise that
(1.20)

- **A.** for every different name an organism has, there is a different taxonomic scheme by which the organism is classified.
- **B.** each scientific name of an organism signifies that it possesses the characteristics defining the group at the applicable taxonomic rank.
- **C.** a genus cannot be defined until all the species in the genus are known and named.
- **D.** a name for an organism is not memorable unless it indicates what other organisms are closely similar to it.

Items 281 - 285. For each of the following organisms blacken the answer space corresponding to the *smallest* group from the list below which includes *both the organism named and man.*

Groups

- **A.** Mammals (class to which man belongs).
- **B.** Vertebrates (subphylum to which man belongs).
- **C.** Animals (kingdom to which man belongs).
- **D.** Primates (order to which man belongs).
- **E.** Chordates (phylum to which man belongs).

281. Paramecium. (1.20)
282. Fish. (1.20)
283. Snail. (1.20)
284. Horse. (1.20)
285. Chimpanzee. (1.20)

286. Individual differences, as a *basis* for action of natural selection, are differences between
(3.00)

- **A.** brothers in the same litter.
- **B.** parents and offspring.
- **C.** individuals of the same age range within an interbreeding group.
- **D.** individuals of generations existing at successive times within a species.
- **E.** closely related species inhabiting different localities.

287. According to Darwin, natural selection is the inevitable result of the existence of individual differences and
(1.20)

- **A.** the existence of different conditions of life.
- **B.** the length of time during which living organisms inhabited the earth.
- **C.** the proportion of the number of individuals born, to the number which the environment can support until reproductive maturity.
- **D.** the similarities between individual differences within a variety, varietal differences within a species, and species differences within a genus.
- **E.** the relationship between living organisms revealed in the taxonomists' classification.

288. In order to develop his theory of natural selection as the agent of evolution, Darwin must postulate that
(3.00)

- **A.** all the individuals in each generation best fitted to their environment live longer and have more offspring than the others.
- **B.** the deaths of individual organisms occur at random with respect to the environment.
- **C.** some of the deaths of individual organisms are dependent on the degree to which they are fitted to the environment.
- **D.** most of the deaths of individual organisms occur due to hereditary deficiencies soon after fertilization.

289. The major aspect of Darwin's theory of evolution which could best be supported by the geological record is that
(3.00)

- **A.** today's species are modified descendants from other, earlier species.
- **B.** natural selection proceeds by the accumulation of individually slight variations, not by large, discontinuous steps.
- **C.** more individuals in a species are born in a year than there is food enough to support.
- **D.** the struggle for existence is most severe between the most nearly related organisms.
- **E.** species which are less well adapted to their environment than others become extinct.

290. The major aspect of Darwin's theory of evolution which is supported by a comparison of adult structures of species within the same genus, of genera within the same family, etc., is that
(3.00)

- **A.** the higher the taxonomic category, the more remote the ancestral species from which all members in that category arose.
- **B.** species which are less well adapted to their environment than others become extinct.
- **C.** more individuals in a species are born in a year than there is food enough to support.
- **D.** the struggle for existence is most severe between the most nearly related organisms.

291. Which of the following is present in the frog but absent in man?
(1.20)

- **A.** Brachial artery.
- **B.** Hepatic portal vein.
- **C.** Pulmonary artery.
- **D.** Pulmonary vein.
- **E.** Renal portal vein.

Items 292 - 294. Eyes of animals may be characterized by

- **A.** low acuity and low sensitivity.
- **B.** low acuity and high sensitivity.
- **C.** medium acuity and medium sensitivity.
- **D.** high acuity and high sensitivity.
- **E.** high acuity and low sensitivity.

292. Which of these do nocturnal animals show?
(1.20)

293. Which of these do diurnal animals show?
(1.20)

294. Which of these do 24-hour animals show?
(1.20)

295. In which of the following is man unique among the living things on the earth?
(1.20)

- **A.** The degree to which his special senses have been developed.
- **B.** His ability to profit by the accumulated experience of the species.
- **C.** His numerical superiority among the organisms occupying the earth.
- **D.** His superior physical strength and endurance among the organisms occupying the earth.
- **E.** His freedom from competition in the struggle for existence.

Items 296 - 302. Certain conditions as to animal coloration may be designated as follows:

- **A.** aggressive resemblance
- **B.** aggressive mimicry
- **C.** protective mimicry
- **D.** protective resemblance
- **E.** warning coloration

How would the following be designated?

296. Resemblance of certain spiders to ants.
(1.20)

297. Black and white coloration of the skunk.
(1.20)

298. Similarity of Monarch and Viceroy butterflies.
(1.20)

299. White color of the polar bear.
(1.20)

300. Red-brown coloration of the Monarch butterfly.
(1.20)

301. White color of Arctic hare.
(1.20)

302. White color of northern weasel in winter.
(1.20)

303. Darwin explains the existence today of such lower
(1.20) forms as amoeba, hydra, and so forth, by assuming that

- **A.** some forms of life have been created more recently than others.
- **B.** they inhabit regions of the earth which have been isolated since soon after the first appearance of life on this earth.
- **C.** there is little tendency to vary in these species.
- **D.** these species are becoming extinct.
- **E.** their simple organization is well suited to their conditions of life.

304. Darwin explains the extinction of intermediate varieties
(1.20) in the formation of two distinct species from one as due to

- **A.** the lack of overlap in range between varieties of the same species.
- **B.** the fact that all varieties of a species live together in the same region.
- **C.** competition being strongest when two organisms have the greatest number of living requirements in common.
- **D.** the intermediate variety lacking the favorable inheritance from the original parent species.

305. Darwin believes that, other things being equal, the
(1.20) larger the area populated with a certain density by a species, the

- **A.** more new variations will appear in the species.
- **B.** more rigorous the selection of the traits of the species.
- **C.** greater the tendency that a new variation will be inheritable.
- **D.** greater the tendency for each individual to present a new variation.
- **E.** lower the geometrical ratio of increase of the species.

306. Darwin would expect new species to be formed most
(1.20) rapidly in a

- **A.** large continental area whose geographical and geological features have remained constant over long periods of time.
- **B.** small isolated island already well stocked with diverse forms of life.
- **C.** thinly populated region in which the conditions for life are uniform throughout.
- **D.** large continental area with diversified geological features which is subject to changes in level relative to the ocean.

307. Which of the following features of bird construction
(1.20) developed most recently?

A. Claws. **B.** Egg-laying. **C.** Feathers.
D. Hollow bones. **E.** Scales on legs.

Items 308 - 314. From the key list below, select the answer which best completes each of the following statements.

KEY

- **A.** Neither man nor amoeba
- **B.** Man but not amoeba
- **C.** Both man and amoeba
- **D.** Nonliving parts of man and amoeba
- **E.** Amoeba but not man

308. Hydrolosis takes place in________.
(1.20)

309. Excretion takes place in________.
(1.20)

310. Hemoglobin is found in________.
(1.20)

311. Special reproductive cells are found in________.
(1.20)

312. Protein synthesis takes place in________.
(1.20)

313. A contractile vacuole is found in________.
(1.20)

314. Cellulose cell walls are found in________.
(1.20)

315. All animals with a true coelom have or display
(1.20)

- **A.** a cuticle. **B.** segmentation.
- **C.** a single, multi-chambered heart.
- **D.** a single median brain, or two brain lobes.
- **E.** separate musculature for the body wall and the digestive tract.

316. Which of the following circulatory patterns best charac-
(1.20) terizes insects?

- **A.** Blood and undifferentiated blood vessels.
- **B.** Arteries, blood, heart, and tissue spaces.
- **C.** Arteries, blood, capillaries, heart and veins.
- **D.** Blood, capillaries, veins, and pulsatile arteries.
- **E.** Arteries, blood, capillaries, veins, and multiple hearts.

317. The complex reproductive system of the earthworm is
(1.20) most useful in promoting

- **A.** cross fertilization.
- **B.** high rate of egg production.
- **C.** internal fertilization. **D.** self fertilization.
- **E.** societal organization among populations of earthworms.

Items 318 - 327. Evidences for evolution may be cited from:

A. Distribution. **B.** Ontogeny. **C.** Homology.
D. Physiology. **E.** Vestigial organs.

To which of the above may the following be assigned?

318. Kiwi.
(1.20)

319. Similarity of bones in limbs of man and other mammals.
(1.20)

320. (1.20) Use of insulin in treating diabetes.

321. (1.20) Exopodites on the walking legs of the lobster.

322. (1.20) Similarity of lice living on different members of the camel family.

323. (1.20) Presence of gill arches and visceral clefts in developing birds and mammals.

324. (1.20) Optic chiasma in vertebrates.

325. (1.20) Snails of the Society Islands.

326. (1.20) Similarity of blood groups in apes and man.

327. (1.20) Pelvic girdles in snakes.

328. (1.20) Which kind of nutrition was probably used by the first living organism on earth?

A. Autotrophic. **B.** Holozoic. **C.** Saprozoic.
D. Heterotrophic. **E.** Saprophytic.

329. (1.20) The phylum to which one of the animals listed belongs has probably existed on the earth longer than the phyla to which the others belong. Which one?

A. Crayfish. **B.** Earthworm. **C.** Hydra.
D. Ascaris. **E.** Planarian.

Items 330 - 337. In dealing with evolution we use the following terms:

A. Cenogenetic character. **B.** Convergence.
C. Palingenetic character. **D.** Persistent type.
E. Isolation.

To which of the above may the following be referred?

330. (1.20) Gastrula stage in the frog embryo.

331. (1.20) Gill clefts in human embryo.

332. (1.20) Horseshoe or king crab.

333. (1.20) Lungfish.

334. (1.20) Pupa stage of Drosophila.

335. (1.20) Shark and dolphin.

336. (1.20) Suckers of frog tadpole.

337. (1.20) Pearly nautilus.

Items 338 - 342. Blood groups or types:

A. O. **B.** A. **C.** B. **D.** AB.
E. O, A, B, AB.

338. (1.20) Which of the blood groups can act as donor for the largest number of types of recipients in an emergency?

339. (1.20) Which group can act as recipient for the greatest number of types of donors in an emergency?

340. (1.10) Which group is rarest among human beings?

341. (1.10) Which group is rarest among monkeys?

342. (1.10) Which does man share with the anthropoid apes?

For items 343 - 348 use the key to indicate which principle bears the most significant relationship to the statements.

KEY

A. The physical and biotic phases of the environment are never stable but always in a state of change. These changes are frequently cyclic.
B. The population size of a species is the result of the interaction between the theoretical capacity of that species to reproduce its kind and the resistance of the environment.
C. Adaptation is a fundamental characteristic of all living things.
D. Social groupings among individuals often increase the chances for survival of the individuals involved.
E. Conservation of natural resources follows man's understanding of the interrelationships among living things.

343. (1.30) The very effective flaps of skin between the toes of a duck are not necessarily the result of conscious effort on the part of the duck.

344. (1.30) Were it not for a sequence of events, the clock of life would have run down millions of years ago.

345. (1.30) The sparrow introduced into the United States became quite a pest during the days of horse-drawn vehicles.

346. (1.30) A school of fish can live in an environment that would not support a solitary individual.

347. (1.30) In Northern Canada and in Norway, vast numbers of little ratlike animals known as lemmings, when their living space has become overcrowded, pour down from the uplands periodically, and after crossing the coastal plains press onward and plunge into the sea where they disappear in mass suicide.

348. (1.30) The smaller the colony of herring gulls, the longer is the period of time through which eggs are laid and the fewer the number which live and grow to maturity.

349. (1.30) The underlying fundamental characteristic(s) of evolution is/are

A. improvement of organisms. **B.** fixity of species.
C. the origin of man from monkey or ape ancestry.
D. change in living things. **E.** all of the above.

350. (1.30) Which of the following reflects the Special Creation Theory?

A. Living organisms occasionally undergo mutation.
B. Natural selection is responsible for the origin of many new species.
C. Each species type was fixed once and for all in antiquity.
D. Acquired characteristics can be transmitted to subsequent generations.
E. New species arise as a consequence of physicochemical phenomena.

351. (1.30) The theory that the individual animal in its development from egg to adult passes through stages which roughly correspond to stages through which the species has passed in its evolutionary development is known as

A. recapitulation. **B.** mutation.
C. catastrophism. **D.** cosmozoic theory.
E. continuity of the germ plasm.

352. "Cataclysmic Evolution" is a type of rapid evolution that
(1.30) may develop because of

A. the adaptation of a species to a new environment.
B. a fertile cross between two distantly related genera.
C. species production without fertilization.
D. a sterile cross, for example, between a horse and a mule.
E. none of the above.

353. The Lamarckian hypothesis (that acquired characteristics
(1.30) are inherited) is not accepted by most present-day biologists because

A. its reasoning contains one major flaw.
B. as a theory of evolution it is incomplete.
C. a process it assumes to exist has not been demonstrated.
D. although the processes required by the hypothesis have been demonstrated individually, they have not yet been shown to interact as described in the hypothesis.
E. Morgan's research on Drosophila (the fruit fly) definitely disproved the hypothesis.

354. Which of the following might best be called a guiding
(1.30) factor in organic evolution?

A. Mutations. **B.** Recombination.
C. Natural selection. **D.** Crossing over.
E. Linkage.

355. Organic evolution is now considered by biological
(1.30) scientists

A. a somewhat inadequately substantiated theory.
B. a well substantiated hypothesis but not a theory.
C. a generally accepted theory, as is also the manner in which evolution takes place.
D. a generally accepted principle although the manner in which it comes about is in debate.
E. not acceptable, since no well substantiated theory of the manner in which it comes about has as yet been developed.

356. The hypothesis of *uniformitarianism* is a belief that
(1.30)

A. all living things on the earth have a uniform development.
B. the earth has been subjected to a series of catastrophic disturbances at uniformly spaced intervals of time.
C. the earth's past history can be explained and interpreted in the light of what is happening in the present.
D. all geologic and evolutionary processes have always gone on at the same uniform rate and under the same conditions as at present.
E. geological history had its beginning when life first appeared on the earth.

357. "The specialized creatures of today have descended by
(1.30) gradual change from different and usually simpler creatures of the past." This statement

A. explains how evolution has taken place.
B. explains why evolution has taken place.
C. implies that all creatures have become more and more complex.
D. implies that specialized creatures are invariably more complex than their ancestors.
E. contradicts the supposition that organism type was fixed once in antiquity and has remained constant to the present time.

358. Upon which of the following is the modern theory of
(1.30) evolution based?

A. Mankind has descended from ape or monkey ancestry.
B. Organisms that resemble each other closely in basic structure and function are likely to be closely related.
C. Since "like begets like" species have not deviated essentially from their progenitors in antiquity.
D. The present diversity of life on the earth came into being in a relatively short period of time after the earth was formed.
E. None of the above.

Item 359 deleted.

360. Which of the following states the theory of recapitu-
(1.30) lation?

A. The embryos of higher animals pass through stages resembling the adults of lower animals.
B. Single-celled animals continue to form spontaneously in mud, soil, water, and other materials.
C. All animals are built on a single type or archetype.
D. Acquired characters are inherited.

361. The fact that the human embryo has gill slits and a
(1.30) notochord which are reminiscent of stages in the evolution of other classes of backboned animals illustrates the

A. Law of Segregation. **B.** Recapitulation Theory.
C. Inheritance of Acquired Characters.
D. Mutation Theory. **E.** Law of Natural Selection.

For items 362 - 365 select from the five principles below the most closely related principle and mark the corresponding answer space.

Principles

A. There have been profound changes in the climate on the earth.
B. Coordination and integration of action is generally slower in plants than in animals.
C. There is an increasing complexity of structure and function from lower to higher forms of life.
D. All life comes from life and produces its own kind of living organisms.
E. Light is a limiting factor to life.

362. The Arctic and Antarctic regions are sparsely populated.
(1.30)

363. Fossils of primates first appear in the Cenozoic rock
(1.30) strata, while trilobite remains are found in the early Paleozoic rocks.

364. Plants have no nervous system.
(1.30)

365. Large coal beds exist in Alaska.
(1.30)

For items 366 - 370 select from the following key the statement which best applies, then mark the answer space corresponding to its number.

KEY

A. Theory of organic evolution that is accepted by most biologists.

B. Basic assumption upon which most of the evidence of organic evolution is founded.
C. Direct evidence of organic evolution.
D. Indirect evidence of organic evolution.
E. Misconception about the theory of organic evolution.

366. (1.30) Gradual change occurs as a result of the interaction of living organisms (characterized by hereditary variations) and the environment thus determining which organisms of the species will survive.

367. (1.30) Organic evolution is characteristic of animals and plants, but not of man.

368. (1.30) Fossil record of the horse.

369. (1.30) Skeletal homology—similarity of skeleton of horse, man, ape, and frog.

370. (1.30) Similarity of structure indicates relationship.

371. (1.30) "If there are any differences among seedlings, sporelings, fledglings, cubs, and larvae (and there always are); and if these differences are of any importance in securing food or eluding enemies; then it is obvious that the few survivors are likely to differ from the many that perish by just these differences."

This principle can best be identified with

A. Charles Darwin. **B.** Lamarck.
C. Hugo de Vries. **D.** T. H. Morgan.
E. Aldous Huxley.

372. (1.30) Which of the following is evidence that tends to refute the Lamarckian theory of organic evolution?

A. Fish that live in caves are usually blind.
B. The great ant eater has no functional teeth.
C. The human being possesses a vermiform appendix.
D. The mole has minute, almost invisible eyes.
E. The giraffe has a long neck and front legs.

373. (1.30) The principle of evolution states that

A. all animals have developed directly from amoeba.
B. change occurs in the organic world.
C. man evolved from the apes.
D. life originated on another planet.
E. life arises spontaneously.

374. (1.30) How do the principles of genetics and evolution stand in relation to each other?

A. The former are broader and more widely applicable.
B. The principle of evolution is unique to the field of biology while the principles of genetics are not.
C. The principles of genetics contribute to an understanding of the principle of evolution.
D. The principles of genetics never give rise to controversy such as that stirred up by the evolution concept.
E. The principles of genetics and the principle of evolution are independent and unrelated.

375. (2.20) In higher organisms a definite life span is followed by death of individuals but continuation of the species. Which of the following is the best evaluation of biological death?

A. Death is disadvantageous to the species because the individual has spent a long period learning how to adjust to his environment when death removes him from the scene.
B. Death is disadvantageous to the species because it is wasteful of the chemical elements which make up the body.
C. Death is advantageous to the species because it multiplies possibilities of variations and evolutionary change in the species.
D. Death has been characteristic of all individual organisms since the first living thing appeared on the earth.
E. Death can serve no useful purpose because every organism instinctively tries to prolong its life as long as possible.

Items 376 - 380.

The following is a description of a fossil organism as found preserved in the rocks. The organism possessed

1. a backbone.
2. a long tail, flattened horizontally at the end.
3. four limbs of approximately equal length and size.
4. a body with neither hair nor feathers (skin not slimy in all probability).
5. the "little" finger of the fore limbs greatly extended a number of times the length of the body.
6. a broad weblike membrane extended between the long little finger of the fore limbs and the hind legs; and between the hind legs and the tail, the membrane in appearance somewhat like the wing of a bat.
7. bones of the skeleton hollow and light.
8. digits, other than the "little" finger of the fore-legs, with claws.
9. sharp slender teeth lining the jaws.
10. (probably laid land eggs).
11. Other fossil associates are dinosaurs and certain amphibians.

376. (2.20) The organism was

A. a bird. **B.** a mammal. **C.** a reptile.
D. an amphibian. **E.** a fish.

377. (2.20) Its chief means of locomotion was by

A. walking. **B.** flying. **C.** crawling.
D. jumping. **E.** swimming.

378. (2.20) The animal was probably

A. warm blooded. **B.** cold blooded.
C. warm blooded during part of its development.
D. bloodless (like the hydra).

379. (2.20) The animal lived probably in

A. an arctic climate.
B. subarctic climate (such as Northern Canada).
C. temperate (such as Michigan).
D. subtropical (such as Florida).
E. desert (such as Arizona).

380. (2.20) Its teeth were adapted to

A. grazing (like horse).
B. browsing (eating leaves and twigs like deer or giraffe).
C. gnawing (rat). **D.** insect eating.
E. stabbing (like the walrus and seal).

381. (2.20) Which one of the following type organisms seems to have the greatest possibility of survival as the environment changes?

- **A.** The organism that is highly developed and specialized.
- **B.** The organism that is adaptable and usually smaller in size.
- **C.** The organism that is dependent upon one other species for its food.
- **D.** Two of the above. **E.** None of the above.

382. (2.20) Which of the following principles is perhaps most closely correlated with the evolution of the long folded intestine in the mammals from the straight, less undulating kind of intestine in fishes?

- **A.** When a sphere increases in size its volume increases as the cube of its diameter, while the surface increases merely as the square of the diameter.
- **B.** The elementary parts of all tissues are formed of cells.
- **C.** Growth is due to an increase in the amount of protoplasm.
- **D.** Protoplasm arises only from pre-existing protoplasm.
- **E.** Life is dependent on an external source of energy.

383. (2.20) Homology would be exemplified by which one of the following?

- **A.** The claw of a fly and the claw of a squirrel.
- **B.** The wings of a butterfly and the wings of a sea gull.
- **C.** The flippers of a whale and the forelegs of a dog.
- **D.** A pair of allelic genes for hair color.
- **E.** Two contrasting processes, such as respiration and photosynthesis.

384. (2.20) Evidence that great climatic changes have occurred in the past is most strikingly provided by the

- **A.** magnitude of the tropical rain forests.
- **B.** thickness of the Eskimo dog's fur.
- **C.** lava deposits in the vicinity of extinct volcanos.
- **D.** climatic data records kept by the U. S. Department of Agriculture.
- **E.** coal deposits discovered in Antarctica.

385. (2.20) Concerning the old question, "Which came first, the hen or the egg?", select the most appropriate answer listed below.

- **A.** The hen because there cannot be an egg without a hen.
- **B.** The egg because direct observation shows there cannot be a hen without an egg.
- **C.** The hen because the first hen probably developed as a result of a series of minor mutations from an earlier bird form.
- **D.** The egg because reptiles lay eggs.
- **E.** The question cannot be answered.

386. (2.20) Which one of the following gives the only direct (rather than circumstantial) evidence for evolution?

- **A.** Vestigial structures. **B.** Homologous structures.
- **C.** Structural similarities between classes and phyla.
- **D.** The fossil record. **E.** Embryonic development.

In answering items 387 - 390 use the key list below.

KEY

- **A.** The fossil record of life upon the earth.
- **B.** Vestigial structures in man.
- **C.** Comparative morphology and comparative embryology.
- **D.** The data from genetics. **E.** Recapitulation theory.

387. (2.20) Gives the best clue to the processes by which evolution takes place.

388. (2.20) Gives the best account of the rate and course of evolution.

389. (2.20) Most widely and generally used in obtaining an estimate of the degree of kinship that exists between two different species of animals?

390. (2.20) Provides the simplest explanation of the similarities in early stage embryos of many different animals.

Items 391 - 402. After each item number on the answer sheet, blacken space

- **A.** if the item is an example of analogous characteristics.
- **B.** if the item is an example of homologous characteristics.
- **C.** if the item is an example of a synthetic species (hybrid).
- **D.** if the item is an example of a vestigial structure.
- **E.** if the item is an example of a mutant.

391. (2.20) The pistil of a flower – sporophyll of fern.

392. (2.20) The ear muscles in man.

393. (2.20) The flipper of a seal – forelimb of man.

394. (2.20) The tail bones in man.

395. (2.20) Two animals have parts which look alike and function in the same way but which arose from structures which were quite different.

396. (2.20) The bat wing–butterfly wing.

397. (2.20) Albino corn.

398. (2.20) Two parts unlike in function developed from similar structures in two different animals.

399. (2.20) The result of a cross between cabbage and radish.

400. (2.20) The yolk sac in man.

401. (2.20) An organism with a new characteristic which appeared suddenly and is inherited by succeeding generations.

402. (2.20) The offspring of a cross between two known species.

Items 403 - 414. After each item number on the answer sheet, blacken space

- **A.** if the item best illustrates natural selection.
- **B.** if the item best illustrates mutation.
- **C.** if the item best illustrates isolation.
- **D.** if the item best illustrates the theory of inheritance of acquired characteristics.
- **E.** if the item best illustrates hybridization.

403. (2.20) On the islands of Galapagos are giant tortoises, big enough to carry a man. Darwin was impressed by the fact that each island seemed to have its own kind of tortoise. Ten different kinds of tortoise were found on ten adjacent islands, and five kinds in different corners of the largest island, which is called Albemarle.

404. (2.20) Chameleons are lizards specialized for arboreal life. The tail is prehensile, and moves in an unusual way—dorso-ventrally, so that it can be readily coiled around the branch. The hands and feet are split in halves, the better to grip the support. The color changes rapidly and is often a concealment.

405. (2.20) If a group of people migrates to a tropical country and is there subjected to intense sunlight, with skin pigment formation or tanning, their children will be born somewhat darker. As a result a darker race will appear in the course of generations.

406. (2.20) The leaf-insect, Phyllium, belonging to the cockroach-locust order Orthoptera, is found in the East Indies, and bears an extraordinary resemblance to a leaf or a number of leaves. It is green in color and the venation of its wings suggests that of a leaf. Moreover, there is a strange flattening of the joints of the legs, suggestive of small leaves.

407. (2.20) When a radish (Raphanus sativus) is crossed with the cabbage (Brassica oleracea), and the resultant plants are self-fertilized or crossed among themselves, a pure breeding, wholly new type of plant is produced (Raphanobrassica).

408. (2.20) A game-cock, in his second year, lost an eye in a fight. Soon after, and while the wound was malignant (it never entirely healed), he was turned into a flock of game hens of another strain. He was otherwise healthy and vigorous. A very large proportion of his progeny has the corresponding eye defect.

409. (2.20) At Hilversun, near Amsterdam, DeVries found a number of evening primroses (Oenothera lamarckiana), an American plant which had been imported into Europe. These plants had escaped from cultivation, and had been growing wild for a period of ten years. They exhibited fluctuating variations in nearly all of their organs. A year after first finding these plants, DeVries observed two well-chararcterized forms which he recognized at once as new species (Oenothera brevisylis, Oenothera laevifolia).

410. (2.20) As many more individuals of each species are born than can possibly survive in the struggle for existence, it follows that any individual organism which varies however slightly in a manner better adapted to the environment will have a better chance of surviving.

411. (2.20) Undoubtedly the first living things reproduced asexually, and sexual reproduction resulted from a chance change that came later. The change probably occurred independently several times among primitive organisms.

412. (2.20) Remains of extinct marsupials are found in many parts of the world, such as Europe and America. The order was once widely represented. Except for the arboreal opossum of North and South America, and the shyselvas of South America, the marsupials are now confined to Australasia. These animals established themselves in part of Australia while that region was connected with the continent of Asia by a great land-bridge across the Java Sea.

413. (2.20) If the pollen from a plant with white flowers is placed on the pistil of a plant with red flowers, the seeds that are produced give rise to a plant with pink flowers.

414. (2.20) Practical growers have observed from time to time that among hundreds of thousands of plants of a given strain, there sometimes appear individuals with characters markedly different from those of the general "population" and which breed true for the characters in question. Such variations are inherited because some change in the chromatin material has accompanied their appearance.

415. (2.20) Direct evidence of evolutionary change in the life of the past is offered by

A. domestication. **B.** experimental breeding.
C. isolation. **D.** the fossil record.
E. natural selection.

416. (2.20) "The mystery of life will always remain. Science is not the death, but the birth of mystery, awe, and reverence." Donnan.

- **A.** Modern investigations, such as those on atomic energy or on the development of a drug such as penicillin, have made false the second sentence of the quotation.
- **B.** Darwin in his "Origin of Species" dissolved the mystery of life when he described organic evolution.
- **C.** The first sentence of the quotation is false, the mystery of life having been solved by the discovery of viruses.
- **D.** Donnan means here that scientific researches do not dispel the mystery of any scientific phenomena.
- **E.** Donnan means by his second sentence that, although the scientist solves certain specific problems the solution of these problems often reveals new problems more mysterious or awe inspiring than those first encountered.

417. (2.20) There are two different fossil forms, each representing different phyla, found in the undisturbed rock layers of a cliff. One of these is the early amphibian, Onychopus. It is found in a rock layer near the top of the cliff. The other form found in the rock layers below the amphibian is

A. a dinosaur. **B.** a primitive dog.
C. the primitive bird, Archeopteryx.
D. a snake. **E.** a fish.

418. (2.20) Charles Darwin, one of the world's greatest biologists, says in his "Descent of Man" (p. 447), "On the other hand some intelligent actions, after being performed during several generations, become converted into instincts and are inherited, as when birds on oceanic islands learn to avoid man."

- **A.** This statement seems reasonable and should be accepted on the authority of Darwin who spent some time on the South Sea islands.
- **B.** Proof of a statement should not be accepted on the evidence presented by any one man.
- **C.** It is known that intelligent actions (actions of thought) are commonly inherited either as instincts or as thought actions. Thus the statement needs no further substantiation.
- **D.** The statement makes a reasonable hypothesis which should be checked more thoroughly before being accepted.
- **E.** It is commonly accepted that wild animals (including birds) become wary of man after association with him. Thus the statement needs no further substantiation

419. (2.20) Alfred Wallace, who reached approximately the same conclusions concerning evolution as Darwin and lived at the same time, said, "Sir Charles Lyell, while agreeing with my main argument on Man, thinks I am wrong in wanting to put him back into Miocene times, and thinks I do not appreciate the immense interval even to the later Pliocene."

According to present evidence,

- **A.** Wallace was right in placing man's first appearance in the Miocene.
- **B.** Wallace should have been even more extreme (in the eyes of Lyell) and placed ancient man's origin in the Eocene.
- **C.** Wallace should have placed the origin of man in the Paleozoic.
- **D.** Wallace was wrong and Lyell right, as man arose in the late Pliocene or early Pleistocene.
- **E.** man first appeared in the Mesozoic.

420. (2.20) Which of the following pairs of structures are *not* homologous?

- **A.** The arm of a man and the foreleg of a horse.
- **B.** The flipper of a whale and the wing of a bat.
- **C.** The wing of a bird and the forelimb of an ape.
- **D.** The wing of a butterfly and the wing of a bird.
- **E.** The hind leg of a cat and the leg of a man.

Items 421 - 434. After each item number on the answer sheet, blacken space

- **A.** if the item best illustrates the process of natural selection.
- **B.** if the item best illustrates the process of mutation.
- **C.** if the item best illustrates the process of isolation.
- **D.** if the item best illustrates the kind of "evidence" used to "prove" the inheritance of acquired characters.
- **E.** if the item best illustrates the process of hybridization.

Item 421 deleted.

422. (2.20) Near Amsterdam, de Vries found a number of evening primroses, an American plant which had been imported into Europe. These plants had escaped from cultivation, and had been growing wild for a period of ten years. They exhibited fluctuating variations in nearly all of their organs. A year after first finding these plants, de Vries observed two well-characterized forms which he recognized at once as new species. (Confirmed.)

423. (2.20) There are a number of species of cattle, including the humped cattle of India, the wild Java ox, the now extinct wild ox of Europe, etc. A number of crosses between domestic and wild cattle have been successful, especially with the humped Indian cattle. These are now being developed as special breeds for southern climates.

Items 424 - 425 deleted.

426. (2.20) When a radish is crossed with a cabbage and the resultant plants are self-fertilized or crossed among themselves, a pure-breeding, wholly new type of plant is produced. (Confirmed.)

427. (2.20) Australia, although at one time connected with the mainland of Asia, became separated from the latter many thousands of years ago, so that the mammals of the mainland could not interbreed with the Australian mammals. Today the mammalian fauna of Australia differs radically from that of Asia. (Confirmed.)

428. (2.20) Lysenko, a contemporary Soviet biologist, asserts that if a crop of wheat is grown under most favorable conditions, it will yield seed with an improved heredity as a result of the vigorous growth of the parent plants.

429. (2.20) In the island of Oahu, volcanic ridges have been eroded out into a series of valleys, in the bottom of which there is abundant vegetation, although there is little but barren rock in the highlands. Climatic conditions in the different valleys are the same. Gulick discovered that each variety of snail is confined to one definite valley, and claimed that he could estimate the degree of differences between varieties by measuring the distance between the valleys from which they came.

Items 430 - 431 deleted.

432. (2.20) A breakwater constructed at Plymouth Sound caused a sudden slowing of the currents at the mouth of the river emptying into the Sound. This resulted in a sudden increase in the amount of the fine sediment found in the water. The sediment caused the death of large numbers of crabs. It was found that the surviving crabs had a narrower body than those which had been killed.

433. (2.20) Pavlov conditioned white mice to run for food at the sound of a bell. The first generation of mice required 300 lessons for this conditioning process. The second generation required 100 lessons; the third, 30 lessons; and the fourth, only 10. (Unconfirmed.)

434. (2.20) Among the thousands of normal red-eyed fruit flies (Drosophila) that had been bred for many generations by T. H. Morgan, there appeared suddenly in 1910 a single white-eyed fly. This white-eyed condition has bred true from the time of its first appearance. (Confirmed.)

Items 435 and 436 are based upon the following situation.

FLIGHTLESS

The great auk, which became extinct in 1844, was the only bird in the northern hemisphere which could not fly. It lost the power through disuse of its wings.

435. (2.20) "It lost the power (of flight) through disuse of its wings" reflects the theory advanced by

A. Darwin. **B.** Lamarck. **C.** Harvey.
D. DeVries. **E.** Mendel.

436. (2.20) Which one of the following best evaluates the present status of this theory?

- **A.** It has stood the test of time and has been repeatedly substantiated by both scientific and non-scientific observers.
- **B.** It is a major contribution to an understanding of how evolution probably takes place.
- **C.** The theory helps explain how mutations occur.
- **D.** The theory is probably untenable.
- **E.** There is no agreement among present-day scientists regarding the probable validity of this theory.

Items 437 - 443. Read the following selection carefully. It is taken from *Life on the Mississippi*, by Mark Twain.

(1) *"In the space of one hundred and seventy-six years the Lower Mississippi has shortened itself two hundred and forty-two miles. That is an average of a trifle over one mile and a third per year.* (2) *Therefore, any calm person, who is not blind or idiotic, can see that in the Old Oölitic Silurian Period, just a million years ago next November, the Lower Mississippi River was upward of one million three hundred thousand miles long,* and stuck out over the Gulf of Mexico like a fishing-rod. And by the same token any person can see that seven hundred and forty-two years from now the Lower Mississippi will be only a mile and three-quarters long, and Cairo and New Orleans will have joined their streets together, and be plodding comfortably along under a single mayor and a mutual board of aldermen. There is something fascinating about science. One gets such wholesale returns of conjecture out of such a trifling investment of fact."

Directions: For each of the following items select the best answer and mark the corresponding space on the answer sheet.

437. (2.20) Statement (1) about the shortening of the Lower Mississippi is probably

A. a guess.
B. true, because this statement appears in a book.
C. true, because observations of the river's length were made in the period mentioned.
D. false, because rivers never change their length.
E. false, because these measurements could not have been made by a single individual.

438. (2.20) The length of the Lower Mississippi a million years ago as given in statement (2) is

A. a fact.
B. the result of reasoning on the basis of extension of data.
C. an hypothesis. **D.** the result of testing.
E. evidence upholding or disproving an hypothesis.

439. (2.20) Statement (2) was obtained by

A. careful observation. **B.** individual opinion.
C. making a generalization on the basis of facts.
D. using a generalization to arrive at an answer to the problem.
E. extensive reading.

440. (2.20) The validity of statement (2) is

A. impossible to prove or disprove, because one cannot live the length of time indicated.
B. impossible to prove or disprove, because no instruments are available to measure such distances or periods of time.
C. impossible to check, because no geological data are available covering the period of time mentioned.
D. impossible to check experimentally by direct measurements.
E. unnecessary to prove or disprove, because the statement is obviously ridiculous.

441. (2.20) Statement (2) is probably:

A. true, because by the process of extrapolation statement (2) follows from statement (1).
B. true, because the statement is obvious.
C. false, because no one ever saw the Lower Mississippi a million years ago.
D. false, because other geological data are ignored.
E. difficult to prove either true or false.

442. (2.20) The shortening of the Lower Mississippi is probably due to

A. erosion of that portion sticking "out over the Gulf of Mexico like a fishing rod."
B. an encroachment of the Gulf of Mexico on the land.
C. an increase in the width of the Mississippi.
D. a decrease in the number of curves and a straightening of the river channel.
E. a decrease in the amount of water carried by the river.

443. (2.20) A science teacher might use this selection to

A. show that one cannot make wholesale conjectures based on incomplete data.
B. show that he understands the geology of the Lower Mississippi.
C. show that science is fascinating.
D. show the reaction of a calm person, who is neither blind nor idiotic.
E. present a history of the Lower Mississippi.

444. (2.20) Which one of the following statements is believed by most scientists to represent the manner in which evolution comes about?

A. A land bird going to seek food in the water would spread its toes to strike the water in moving about. Thus the skin at the base of the toes would be continually stretched, and muscular movements of the legs would promote an extra flow of blood to the feet. In consequence the skin would become enlarged as webs between the toes, such as are seen in ducks.
B. Some internal or yet unknown force directs the evolution of a part along some line of development, as in the evolution of horns from small nubbins to large unwieldy growths in the titantotheres (extinct mammals); or in the progressive enlargement of the teeth of the horses during their evolution.
C. Small fluctuating variations make their possessors more adapted to their environment than others of the same or different species, which place their possessors at an advantage in the struggle for existence, perpetuating them while the others perish. As an example, a fleet wild horse and his mate, who can outrun rivals and enemies, survive to reproduce similar fleet-footed offspring. These offspring survive rather than their slower brethren.
D. Some mutations give to their possessors an advantage in the struggle for existence, permitting them to survive when others of their kind or of a competing species perish. Their offspring inherit such advantages and thus perpetuate the kind. As an example, dun-colored grasshoppers live among the clumps of grass on a white sandy beach. A white mutant appears. The white color places the grasshopper at an advantage in that the color is more protective. It reproduces white offspring which survive, rather than the dun-colored type, in the struggle for existence.
E. Species change in direct response to changes in their environment, that is, the environment causes the change in the plant or animal. Thus the cooling of the climate would cause the mammoth to develop hair on the body to protect it from the cold.

Items 445 - 450 are concerned with the following situation:

A naturalist noticed that a small windswept island about one hundred miles off the coast of New Guiana was thickly populated with a wingless species of insect. These insects appeared to be very similar to a species that he had studied on the mainland of New Guiana except that the mainland insects had wings. Evaluate the following notes recorded by the naturalist according to the key.

KEY

- **A.** An exact scientific law.
- **B.** A theoretical explanation advanced to account for observed data.
- **C.** A correct definition or highly probable observation.
- **D.** A false statement or impossible observation.

445. (2.20) If an organism does not make use of certain organs in adapting to a specific environment, these organs will degenerate and disappear.

446. (2.20) The larvae of the mainland and island insects both had sixteen pairs of legs.

447. (2.20) Certain organs that may permit a species to survive in one environment may lead to its extinction in another environment.

448. (2.20) The island flies did not require wings in order to survive.

449. (2.20) Which of the following hypotheses regarding the above problem does current biological science indicate as the most favorable?

- **A.** When these flies first appeared on the earth they were identical except that some had wings. Those with wings could not live on the windswept island.
- **B.** The flies were originally all winged individuals. A mutation occurred which produced some wingless individuals which were better able to survive on the island.
- **C.** The length of the wings of all flies varies a little. Those flies with the shorter wings would be favored in the windswept environment and reproduce more rapidly than the winged individuals.
- **D.** The island environment did not favor the use of wings thus leading to degeneration and subsequent disappearance of wings.

450. (2.20) Which of the hypotheses listed in the preceding item would be strengthened most by this observation: Several thousand eggs of the mainland insects were irradiated with X-rays. A few wingless individuals hatched from these eggs. These wingless individuals produced wingless individuals.

451. (2.20) At the present time about 158,000,000 tons of sodium are being added to the oceans annually. The sodium content of the oceans is now 16,000,000,000,000,000 tons. How would this evidence be evaluated in relation to its usefulness in determining the age of the earth?

- **A.** This constitutes positive proof that the earth is at least 100,000,000 years old.
- **B.** This data is of doubtful value as evidence having any bearing upon the approximate age of the earth.
- **C.** This data indicates that the earth is probably very old.
- **D.** The earth is about 6,000 years old; no "evidence" will change that fact.
- **E.** Nobody could possibly know either how much sodium there is in the oceans or how much is added each year.

Items 452 - 459. Suppose that Linnaeus, Lamarck, Darwin, Mendel and a contemporary biologist (not a Russian biologist) are broadcasting a round-table discussion from station WXYZ in Erewhon. Identify the speaker of each *numbered* statement by using the following code:

A. Mendel. **B.** Lamarck. **C.** Darwin.
D. Linnaeus. **E.** The contemporary biologist.

The contemporary biologist begins the discussion by saying, "A few days ago I read the following paragraph in a recently published textbook of biology:

'A population of slow-moving carnivores is established in a region in which plenty of food is available in the form of slow-moving herbivores. Unusual temporary conditions enable some of these carnivores to pass over a barrier into a new region. (Neither these animals nor their descendants ever pass back over the barrier to the old region.) In the new region the only possible food for the carnivores consists of fast-moving herbivores. Many thousands of years later the only descendants of the carnivores that are living in the new region have characteristics that make them fast-moving.'

What is the explanation of this phenomenon?"

452. (2.20) "Well, obviously the explanation is a simple one. Chasing the fast-moving herbivores exercised the legs of the carnivores so that they became more effective means of locomotion. The offspring of these carnivores inherited better legs."

453. (2.20) "I do not think that the case is quite so simple. Could it not be that natural selection acting during thousands of years would suffice to produce the fast-moving carnivores?"

454. (2.20) "I think not! The law of use and disuse tells us that muscles and organs which are exercised much tend to increase in size. The offspring would then inherit the improved legs of their parents. This is a simple example of the inheritance of acquired characteristics."

455. (2.20) "You gentlemen may argue about the mechanism of evolution. I wonder how this new species of carnivore fits into the scheme of classification which I invented?"

456. (2.20) "New species fit very easily into your system of classification. In my book, 'The Origin of Species,' I told how new forms are classified as varieties at first and how they may later become full-fledged species."

457. (2.20) "I think, gentlemen, that, to understand what has actually happened to produce these fast-moving forms, we should set up some breeding experiments similar to those I originated with plants. Our first job is to determine how the new character is inherited."

458. (2.20) "I agree. You notice that the paragraph read to us specifies that the barrier did not allow any animals to return to the original group. This emphasizes the importance of isolation in evolution. Isolation is a significant factor in promoting the selection which Wallace and I stressed as essential."

459. (2.20) "Furthermore, the occurrence of mutations promoting fast movement better fitted such carnivores for survival."

Items 460 - 465 are based upon the following letter to the editor of a western newspaper:

"The evolution which concerns the development of any species after their own kind, is a process to which all intelligent people agree, but when it comes to trying to make people believe that an entirely new species can be developed from any species, such as a man being developed from a monkey, it is the height of the ridiculous. If that were possible, we could certainly have a right to expect that at least the offspring of monkeys in zoos, where they have every opportunity for copying their caretakers and people who daily come to see them, would be found in various stages of development towards becoming a human being."

460. (2.20) The general contention in the letter is based upon a belief in

- **A.** inheritance of intra-species variations.
- **B.** orthogenesis. **C.** natural selection.
- **D.** inheritance of inter-species variations.
- **E.** a theory which is impossible to determine.

461. (2.20) Which of the following is the major idea that the writer is apparently attempting to convey?

- **A.** Man probably developed from the monkey in antiquity.
- **B.** The theory of evolution is the height of the ridiculous.
- **C.** Species sometimes give rise to other new species, but man did not arise from any pre-existing species.
- **D.** While evolutionary change within a species often occurs, one species never gives rise to another species.
- **E.** The writer is an intelligent person.

For items 462 - 465 also refer to the preceding letter. Mark the space

- **A.** if the statement is true and tends to support the argument in the letter.
- **B.** if the statement is true and tends to refute the argument in the letter.
- **C.** if the statement is true but has no direct bearing on the argument.
- **D.** if the statement is false.

462. (2.20) A mule is produced by cross-breeding a mare and a donkey.

463. (2.20) Generally speaking, the offspring of dogs are dogs and the offspring of cats are cats.

464. (2.20) There are dozens and sometimes hundreds of "man-made" varieties of certain cultivated plants, such as peonies, dahlias, roses, and gladiolus.

465. (2.20) A certain geneticist crossed a species of cabbage with a species of radish and obtained a new genus, Raphanobrassica, which has a cabbage-like root and a radish-like shoot. It breeds true, producing progeny which resemble itself.

466. (2.20) Modifications of the usual divisions of the digestive tube are:

- **A.** always associated with the symmetry of an animal.
- **B.** usually associated with the size of an animal.
- **C.** usually associated with unicellular animals.
- **D.** usually associated with the food habits of an animal.
- **E.** rarely found in multicellular animals.

467. (3.00) An albino annual seed plant germinates in an ordinary garden plot. Which of the following is the most likely fate of this organism?

- **A.** Growth to flowering only.
- **B.** Growth until reserve food is exhausted.
- **C.** No growth of such a plant.
- **D.** Continued independent existence.
- **E.** Growth to seed production.

468. (3.00) A primary reason that man has been able to distribute himself throughout the world is his ability to

- **A.** change his body temperature to that of his environment.
- **B.** live solely from inorganic materials.
- **C.** maintain a constant temperature regardless of his environment.
- **D.** utilize carbon dioxide, sunlight, and water to synthesize sugars.
- **E.** regulate his metabolic rate at will.

469. (3.00) The following structures must have been developed by ancient plants before they could successfully have left the water to live upon land as *large* land plants.

- **A.** Chlorophyll, flowers, and cuticle.
- **B.** Cuticle, rhizoids or roots, and vascular tissue.
- **C.** Chlorophyll, cuticle, and flowers.
- **D.** Chlorophyll and cuticle.
- **E.** Vascular tissue and flowers.

470. (3.00) Strong proof of close relationship between species is provided when

- **A.** they occupy the same geographic range.
- **B.** they are found in identical environments.
- **C.** their habits are similar.
- **D.** they possess a high proportion of homologous structures.
- **E.** they react similarly to environmental changes.

471. (3.00) The native mammalian fauna of Australia, before the entrance of man, was composed exclusively of monotremes and marsupials. This is true because

- **A.** placental mammals could not compete with marsupials in the climate of Australia.
- **B.** marsupials and monotremes had radiated into all the available niches, leaving no unoccupied niche for placental mammals.
- **C.** Australia was cut off from the Malay Peninsula before placental mammals reached the continent.
- **D.** marsupials replaced the earlier placental mammals which had been in Australia before it was cut off from the Malay Peninsula.
- **E.** the placental mammals were eliminated by man and his hunting dogs.

472. (3.00) The dependence of Red Clover on Bumble Bees, the Smyrna Fig on Wasps, and the Yucca Plant on a certain Moth were examples of the generalization that

- **A.** flowers always need insects for pollination.
- **B.** insects prefer blossoms to plant stems for food.
- **C.** organisms have particular food habits.
- **D.** organisms evolve together.
- **E.** pollination by insects is least effective.

473. (3.00) Vertebrate animals generally, because of their methods of reproduction, were tied to the water until the reptiles developed internal fertilization and the land egg. Mosses and ferns, although not tied to bodies of water, were dependent upon water in their external environment (rain or dew) for their reproductive processes and were thus limited in their spread over the land surface to moist and humid regions until a process somewhat analogous to internal fertilization evolved by the development of

A. motile sperms. B. conducting tubes in their stems.
C. the pollen tube. D. alternation of generations.
E. an independent gametophyte.

474. (3.00) Which of the following factors plays the most important role in thwarting man's efforts to completely eradicate certain bacterial diseases by means of chemotherapy?

- **A.** Instability in quality of the chemical substances used.
- **B.** The variability of the environmental temperature.
- **C.** Ability on the part of microorganism parasites to find new hosts in almost any species.
- **D.** The great range of individual adaptability on the part of individual microorganisms.
- **E.** Mutations which occur in microorganisms.

Items 475 - 494. After the number on the answer sheet corresponding to that of each of the following paired items, blacken space

- **A.** if the item in Column I precedes the item in Column II in evolution and the items are related in embryonic development.
- **B.** if the item in Column I precedes the item in Column II in evolution and the items are not related in embryonic development.
- **C.** if the item in Column I follows the item in Column II in evolution and the items are related in embryonic development.
- **D.** if the item in Column I follows the item in Column II in evolution and the items are not related in embryonic development.

	Column I	*Column II*
475. (3.00)	Multicellular plant body.	.... Development of cortex of the stem.
476. (3.00)	Ability to make simple carbohydrates.	.... Use of organic substances as a source of food.
477. (3.00)	Independent sporophyte.	.... Flower.
478. (3.00)	Flower.	.... Conspicuous gametophyte.
479. (3.00)	Bilateral symmetry.	.... Radial symmetry.
480. (3.00)	Gametes alike in appearance.	.... Large non-motile egg and small motile sperms.
481. (3.00)	Blastula.	.... Gastrula.
482. (3.00)	Mesoderm formation.	.... Coelom.
483. (3.00)	Land type egg.	.... True placenta.
484. (3.00)	Gastrula.	.... Blood vascular system.
485. (3.00)	Anus.	.... Gastro-intestinal diverticule.
486. (3.00)	Nerve net.	.... Sensory and motor nerve fibers.
487. (3.00)	Eye spots.	.... Stereoscopic vision.
488. (3.00)	Gills.	.... Lungs.
489. (3.00)	Feathered wings of a bird.	.... Wing of a bat.
490. (3.00)	Penis.	.... External fertilization.
491. (3.00)	Placenta.	.... Mammary glands.
492. (3.00)	Placenta.	.... Allantois.
493. (3.00)	Opposable thumb.	.... Claws.
494. (3.00)	Solid ventral nerve cord.	.... Tubular dorsal nerve cord.

495. (3.00) The wings of a butterfly and the wings of a bird are examples of characters that are

A. homologous. B. analogous.
C. radially symmetrical. D. mutations.
E. discontinuous variations.

Items 496 - 499. In a certain area (X) a group was investigating the rock layers of which the sides of a canyon were formed and comparing them with rock layers (Y) about 10 miles away.

496. (3.00) At the height of 4 feet above the ground in X there were found fossil remains of a type of sponge, two types of seaweed and a small arthropod. At site Y at the same height the fossils found were of three types of fern and an insect. This difference is probably due to which of the following?

A. Isolation. B. Temperature change.
C. Mutations. D. Chemical differences.
E. Difference in water relationships.

497. (3.00) A collection of present-day plants was made also. In studying these plants they were classified down to species. It is probable that classification was *not* made on the basis of

- **A.** kind of reproductive structures.
- **B.** presence or absence of vascular tissue.
- **C.** thick or thin epidermis.
- **D.** absence or presence of seeds.

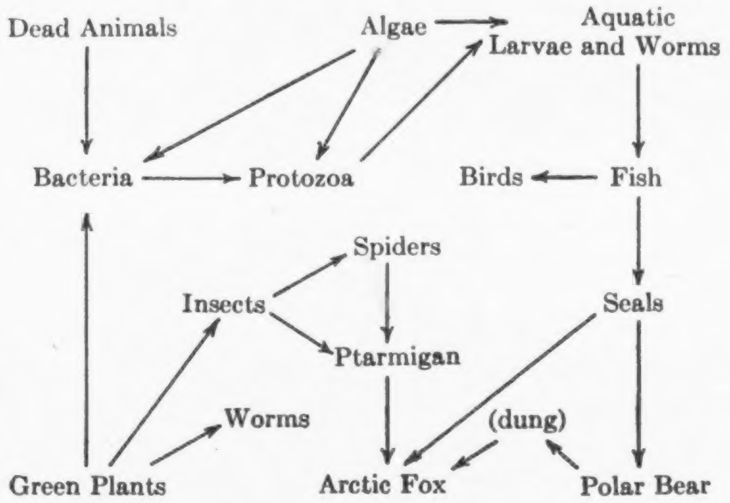
498. (3.00) A present-day form when compared with two extinct forms found at X seems to have some characteristics of each of the fossil forms. The truth is that the present day form

- **A.** must be a hybrid of the other two.
- **B.** is probably a hybrid and proof can be obtained by crossing the other two.
- **C.** couldn't be a hybrid because no fossil of this present-day form was found.
- **D.** might be a hybrid but more investigation is necessary to prove it

499. (3.00) A rock was cracked open and a cast of a piece of plant stem was found within. It was a different type of material from that of the surrounding rock. This would be considered

A. a fossil.
B. not a fossil because it was only part of a plant.
C. not a fossil because it was different material.
D. not a fossil because it was not found associated with coal.

Items 500 - 509. After the numbers on the answer sheet which correspond to those of the following exercises, blacken the one lettered space which designates the correct answer.



The arrows in the diagram above read "eaten by," for example, green plants are eaten by insects which are eaten by spiders, etc.

500. The above relationship illustrates
(3.00)

A. food chain. B. succession. C. biome.
D. climax. E. key industry animal.

501. A. green plants; B. polar bear; C. dead animals;
(3.00) D. fish; E. insects are the foundation of the above relationship as they, either directly or indirectly, constitute the ultimate source of food for the organisms shown.

502. Insects are
(3.00)

A. carnivores. B. symbionts. C. parasites.
D. herbivores. E. saprophytes.

503. Bacteria are
(3.00)

A. carnivores. B. herbivores. C. omnivores.
D. parasites. E. saprophytes.

504. Seals are
(3.00)

A. carnivores. B. herbivores. C. saprophytes.
D. parasites. E. omnivores.

505. Lack of light or a prolonged decrease in light intensity
(3.00) would have a direct, immediate effect upon

A. polar bears. B. bacteria. C. green plants.
D. dead animals. E. protozoa.

506. A sudden decrease in insects would cause a decrease in
(3.00)

A. worms. B. ptarmigans. C. protozoa.
D. green plants. E. algae.

507. Under natural conditions the above relationship is a (an)
(3.00)

A. succession. B. pyramid of numbers.
C. balanced equilibrium. D. key industry animal.
E. association.

508. In the above relationship, the greatest number of organ-
(3.00) isms would generally be found among

A. polar bears. B. birds. C. insects.
D. green plants. E. arctic fox.

509. In the above relationship, the least number of organisms
(3.00) will be found among

A. polar bears. B. birds. C. insects.
D. green plants. E. arctic fox.

510. In 1946 a city sprayed DDT on city dumps and other
(3.00) breeding grounds of flies. This was immediately effective in reducing the number of house flies in the whole city area. Although the spraying was repeated in successive years, the number of flies gradually increased, approaching the former (1945) level in 1949. Which of the following best explains this situation?

A. Each new generation of young flies grew up with DDT as part of the environment and gradually developed immunity.
B. Flies gradually found new breeding places not contaminated by DDT.
C. DDT-resistant flies survived to breed, as did their offspring, until more and more of each year's flies were DDT-resistant.
D. Flies exposed to non-lethal concentrations of DDT quickly learned to avoid food and other matter sprayed with DDT.
E. Flies from nearby, non-sprayed areas soon migrated to the city area.

511. Evolution can take place more rapidly among organisms
(3.00) which reproduce sexually than among those which reproduce asexually.

A. Sexual reproduction is more hazardous than asexual, hence, only the fit survive.
B. Asexual reproduction is possible only for one-celled organisms.
C. Sexual reproduction is more likely to produce a variety of offspring.
D. Sexual reproduction is inferior to asexual reproduction in the rapidity of production of offspring.
E. Mitosis can take place only in organisms that possess sexual reproduction.

512. In general, the animals higher in the scale of vertebrate
(3.00) life can maintain their species with fewer eggs.

A. The higher animals are better adapted to their environments than the lower ones.
B. The higher vertebrates give greater care to their eggs and their offspring.
C. Sexual reproduction is characteristic of the higher animals while asexual reproduction characterizes the lower animals.
D. Internal fertilization characterizes the reproduction of all vertebrates.
E. The higher vertebrates do not produce enough sperms to fertilize as many eggs as are produced by the lower vertebrates.

513. (3.00) The amnion and the shell of the egg are necessary adaptations for land life in some vertebrates.

- **A.** Many land animals do not lay eggs.
- **B.** The amphibia spend part of their lives on land.
- **C.** These structures protect the embryo from drying and mechanical injury.
- **D.** These structures develop from the yolk sac and protect the internal organs.
- **E.** The amnion serves as a source of nourishment for the developing embryo.

For items 514 - 530 blacken space

- **A.** if the item referred to is an example of homologous structures.
- **B.** if the item referred to is an example of analogous structures.
- **C.** if the item referred to is an example of a vestigial structure.
- **D.** if the item referred to is true of none of the above.

514. (3.00) The wing of a bird as compared with the wing of a butterfly.

515. (3.00) The cellular covering of the earthworm and the skin of man.

516. (3.00) A few small tail vertebrae in man.

517. (3.00) Ovaries in hydra, ovaries in the female monkey.

518. (3.00) Man's appendix.

519. (3.00) The skin of a dog, the skin of man.

520. (3.00) Feathers of a bird, scales of a reptile.

521. (3.00) Arm of man and the foreleg of a horse.

522. (3.00) The bone structure of a cat's forelimb and the wing of a bird.

523. (3.00) Blood in man, blood in frogs.

524. (3.00) A few small bones in the hip region of a whale.

525. (3.00) The nictitating membrane in the eye of man.

526. (3.00) Thyroid gland in man, thyroid gland in pigs.

527. (3.00) The eye of a dog and eye of a housefly.

528. (3.00) Hair in dogs, hair in man.

529. (3.00) The caecum of the rabbit, the appendix in man.

530. (3.00) Cilia in paramecium, hair in humans.

For items 531 - 536 blacken space

- **A.** if the item is true of the use and disuse theory of evolution.
- **B.** if the item is true of natural selection.
- **C.** if the item is true of both.
- **D.** if the item is true of neither of the above groupings.

531. (3.00) Involves reactions to the environment over long periods of time.

532. (3.00) Attributed evolution to an instinctive force in an organism causing it to evolve along a particular line regardless of any external factors.

533. (3.00) Animals geographically isolated will produce new species.

534. (3.00) Those animals that best can adapt themselves to changes in the environment because of the general nature of the protoplasm will survive and propagate the species.

535. (3.00) A weight-lifter develops large biceps muscles. He marries a champion female ice-skater. Their children will have large muscles and also be champion ice-skaters.

536. (3.00) Genes segregate independently.

537. (3.00) Mammals are successful with small eggs, while lower vertebrates must produce larger eggs.

- **A.** Mammals tend to produce fewer eggs.
- **B.** Mammals are the only vertebrates that care for their young.
- **C.** The land egg makes it possible for reptiles to live away from bodies of water.
- **D.** Mammalian embryos receive nourishment from the blood of the mother.
- **E.** The blood of the mother circulates through the mammalian embryo.

For items 538 - 541 use the following key:

KEY

- **A.** A is the cause of B. **B.** A is the effect of B.
- **C.** A is an assumption, B is evidence that supports it.
- **D.** A is an assumption, B is evidence that contradicts it.
- **E.** A and B are two facts but not related in any of the above ways

538. (3.00)
- **A.** Organisms that are similar are related and the greater the similarity the closer the kinship.
- **B.** Some of the progeny of man are identical.

539. (3.00)
- **A.** Natural environmental resistances are changed artificially with antibiotics and insecticides.
- **B.** Non-mutating individuals are unable to survive.

540. (3.00)
- **A.** Many species have become extinct during the past geological periods.
- **B.** There were no suitable mutants.

541. (3.00)
- **A.** A gene synthesizes a copy of itself from non-genic materials.
- **B.** Genes determine patterns of development which result in the emergence of traits such as eye color and skin pigmentation.

542. (3.00) In which one of the following ways do plant disease-producing organisms tend to offset man's efforts to eliminate them?

- **A.** The disease-producing organism shifts to a different host on which it may be even more destructive.
- **B.** The disease-producing organism may deliberately go into a period of prolonged dormancy only to return when man has again relaxed his surveillance.

C. The disease-producing organisms may shift for a period of time to animal hosts, mutate, and then later shift back to a different plant host.
D. The disease-producing organism often mutates to form a new strain to which the plant is not resistant.
E. The disease becomes endemic for a period of time after which it breaks out again into epidemic proportions.

543. (3.00) Darwin, in discussing the reversions of pigeon breeds, states that reversion to introduced "foreign" blood does not occur after twenty generations after the cross. For such a "reversion" to occur (after, for example, the fifth generation), the trait, if due to a single gene, must be considered as due to

A. a sex-linked gene. **B.** an autosomal gene.
C. a dominant gene. **D.** a recessive gene.
E. a dominant, sex-linked gene.

544. (3.00) If all the matings following the cross (item 543) had been exclusively to pure-bred pigeons in the breed, the chance that a particular twentieth generation descendant of such a cross would be hybrid for a particular one of the genes introduced by the "foreign" ancestor is nearest to

A. zero. **B.** ½. **C.** ¼. **D.** $(\frac{1}{2})^{10}$. **E.** $(\frac{1}{2})^{19}$.

545. (3.00) A role of intercrossing in evolution not emphasized by Darwin but undoubtedly operative in view of the mechanism of inheritance established by Mendel and extended by Morgan, is that

A. it decreases the amount of divergence from "type" of the individuals of a species.
B. it increases the number of combinations of traits in the individuals of a species without increasing the number of kinds of hereditary units.
C. it renders individuals less vigorous and less able to compete with individuals in other species.
D. it increases the probability of reversion to ancestral types.
E. it permits the spread of favorable new variations throughout a population.

For items 546 - 554 consider the data presented in the table below.

Four different mutant strains were obtained in Neurospora crassa by X-rays in the manner indicated by Beadle. In the following table, the symbol (+) indicates that the strain could grow on the indicated medium. The symbol (○) indicates lack of growth.

Medium Strain	#1	#2	#3	#4
minimal	○	○	○	○
minimal + thiamine	+	+	+	+
minimal + thiazole	+	○	+	○
minimal + pyrimidine	○	+	○	○

Assume that in each strain X-rays have caused only one gene to mutate, and that the above is the result of these mutations. Two strains of *Neurospora* can be "fused," so that nuclei of both are present in the same cytoplasm. Thus, if each strain had the gene for which the other was defective, the fusion product would have a normal metabolism.

546. (3.00) From the data, Beadle would infer that the deficiency in the case of strain 2 is an inability to synthesize

A. thiamine from its immediate components.
B. pyrimidine from its immediate components.
C. thiazole from its immediate components.
D. both pyrimidine and thiamine, from their chemical components.
E. both thiazole and thiamine, from their chemical components.

547. (3.00) From the data, Beadle would infer that the deficiency in the case of strain 3 is an inability to synthesize

A. thiamine from its immediate components.
B. pyrimidine from its immediate components.
C. thiazole from its immediate components.
D. both pyrimidine and thiamine, from their chemical components.
E. both thiazole and thiamine, from their chemical components.

548. (3.00) From the data, Beadle would infer that the deficiency in the case of strain 4 is an inability to synthesize

A. thiamine from its immediate components.
B. pyrimidine from its immediate components.
C. thiazole from its immediate components.
D. both pyrimidine and thiamine, from their chemical components.
E. both thiazole and thiamine, from their chemical components.

549. (3.00) If the synthesis of thiamine involved the production first of thiazole, then of pyrimidine from thiazole, and lastly of thiamine from pyrimidine (thiazole → pyrimidine → thiamine), it would follow that the mutant strain "thiazoless" would

A. not be able to grow on "minimal + thiamine."
B. not be able to grow on "minimal + pyrimidine."
C. not be able to grow on "minimal + thiazole."
D. be able to grow on "minimal + pyrimidine" as well as "minimal + thiazole" and "minimal + thiamine."

550. (3.00) From the data, it would seem that the synthesis of thiamine involves

A. the addition of some unknown component to pyrimidine.
B. the addition of some unknown component to thiazole.
C. the combination of pyrimidine and thiazole.
D. the putting together of as yet unknown components; breakdown of thiamine yielding pyrimidine and thiazole.
E. the production first of pyrimidine, then of thiazole from pyrimidine, and lastly of thiamine from thiazole.

551. (3.00) To explain the data, a minimum number of gene loci which one can assume to have been affected is

A. one.
B. two: one in two of the strains and one in the other two strains
C. three: one in two strains and one in each of the other two strains.

552. (3.00) When two recessive mutant strains of *Neurospora* are allowed to "fuse," inability to grow on minimal medium indicates that

A. the mutations in the two strains are at different loci.
B. the two mutations affect the same stage in a process.
C. the two mutant genes are on the same chromosome.
D. the two mutations are at the same locus.
E. the mutations are identical.

553. (3.00) When two mutant strains of *Neurospora* are allowed to "fuse," ability to grow on minimal medium is evidence that

A. the mutations in the two strains are at different loci.
B. the mutations in the two strains are on different chromosomes.
C. the mutations in the two strains are allelic.
D. the two mutations affect different processes.
E. both mutations are dominant.

554. (3.00) On the assumption that the minimal number of gene loci have been affected (see item 551), you would predict that abnormal metabolism would be obtained in the resultant of a "fusion" between strains

A. 1 and 2. **B.** 1 and 3. **C.** 1 and 4.
D. 2 and 3. **E.** 2 and 4.

555. (2.20) Beadle's chief experimental conclusion is that

A. genes are nucleo proteins.
B. the function of genes is to synthesize protein.
C. genes determine the nature of the cytoplasm.
D. genes are of two types: those which produce enzymes which in turn determine observable characters, and those which affect character directly.
E. when a single gene is modified, a single chemical reaction fails to take place.

556. (2.10) Beadle's one-gene-one-enzyme hypothesis is best stated as

A. the direct action of each gene is the production of a specific type of enzyme.
B. each enzyme is produced by a single gene.
C. the type of enzyme produced by a gene depends on the type of substrate present.
D. each morphological character is produced by a specific enzyme, which in turn was produced by a single gene.
E. the one property common to all genes is their ability to influence chemical reactions.

557. (2.20) Beadle's one-gene-one-enzyme hypothesis is inconsistent with

A. East's hypothesis of multiple factors since, while several loci might produce the same enzyme, it is highly unlikely that their separate effects would be cumulative.
B. Spemann's hypothesis of cytoplasmic differentiation since it is highly unlikely for cytoplasmic differences to arise independently of mutation.
C. Weismann's hypothesis of nuclear differentiation since, according to Beadle, enzymes in the cytoplasm are the determiners of metabolism.
D. Spiegelman's evidence of enzymatic adaptation since, according to Beadle, if a gene is present, the enzyme it produces must be present in the cytoplasm.
E. Waddington's view of competition between genes for raw materials since the "one-to-one" hypothesis implies independence between genes, i.e., interaction between genes is denied.

558. (2.20) Beadle's evidence that the inability to synthesize certain substances in *Neurospora* is *genetic* is that

A. the same inability persists for generations.
B. the results of crosses follow the expectations of Mendelian theory, assuming that the vegetative or asexual stage is haploid.
C. fusion products of mutant plus wild types can grow on minimal medium.
D. the spore sac contains almost no cytoplasm.
E. certain morphological traits are almost invariably associated with each of the biochemical traits.

Items 559 - 565. In establishing that the breeds of pigeons are all descended from the rock pigeon, *Columba livia,* Darwin cites several lines of evidence whose relevance depends on the validity of several assumptions.

Directions: For each of the numbered statements of evidence, *blacken* the answer space pertaining to the *one* assumption in the list below which must be valid if the evidence is to prove Darwin's point.

Assumptions

A. Hybrids between distinct species are seldom perfectly fertile.
B. Species which are especially well suited to their conditions of life flourish; species do not arise in nature which are not suited to their conditions of life.
C. The potentialities for producing the ancestral type are inherited and occasionally appear as reversions.
D. The more particularly an organism is observed, the greater is man's power of selection.
E. Only a small proportion of wild species breed freely under confinement.

559. (4.20) "On the hypothesis of the multiple origin of our pigeons, it must be assumed that at least seven or eight species were so thoroughly domesticated in ancient times by half civilized man, as to be quite prolific under confinement."

560. (4.20) "The supposed aboriginal stocks must all have been rock-pigeons, that is, they did not breed or willingly perch on trees. . . . Hence the supposed aboriginal stocks must either still exist in countries where they were originally domesticated, and yet be unknown to ornithologists, . . . or they must have become extinct in the wild state."

561. (4.20) "The several . . . domesticated breeds have been transported to all parts of the world, and, therefore, some of them must have been carried back again into their native country; but not one has become wild or feral, though the dovecot-pigeon, which is the rock-pigeon in very slightly altered state, has become feral in several places."

562. (4.20) "The wild *Columba livia* has been found capable of domestication in Europe and in India."

563. (4.20) "Pigeons have been watched and tended with the utmost care, and loved by many people. They have been domesticated for thousands of years in several quarters of the world."

564. (4.20) "I then crossed one of the mongrel barb-fantails with a mongrel-spot, and they produced a bird of as beautiful a blue colour, with the white loins, double black wing-bar and barred and white-edged tail feathers, as any wild rock-pigeon!"

565. (4.20) "From long-continued study, (the breeders) well know that each race varies slightly, for they win their prizes by selecting such slight differences."

Directions: For the following items (566 - 576) on Darwin's *Origin of Species, blacken* the answer space corresponding to the *one best answer.*

566. (2.20) Darwin considers that the best clue as to the *reason* for domesticated races having the characters they have is in

A. the endless slight variations which appear within the races.
B. the exaggerated differences of only a few of the characters in the different races of the same species.
C. their adaptation to man's use or fancy, rather than to their own good.
D. the great length of time during which they have been tended by man.
E. man's esteeming the slight differences which distinguish his from another's possessions.

567. (2.20) The role ascribed to the process of variation in the production of distinct breeds is that of

A. delimiting the possible types of breeds to be produced.
B. furnishing the basis for the modification of characters by use or disuse.
C. making visible the effects of long-continued selection.
D. providing the materials for selection to preserve or discard.
E. preserving the diversity of breeds when these are once established as distinct.

568. (2.20) The role ascribed to the process of selection by man in the production of distinct breeds is that of

A. rendering species interfertile and adaptable to a variety of climates, the rest being the result of intercrossing and the definite action of diverse conditions of life.
B. promoting an increase in the tendency of cultivated organisms to vary.
C. decreasing the tendency of newly-formed breeds to revert to their original wild-type constitution.
D. accumulating successive slight variations by breeding chiefly from the possessors of these variations.
E. determining the ideal type of organism to be produced, then breeding from those individuals most nearly resembling the ideal.

569. (2.20) The *criterion* Darwin uses to distinguish the more variable species from the less variable species in Chapter II is

A. number of individuals in the species.
B. frequency of individual differences in the species.
C. number of varieties in the species.
D. number of closely related species.
E. number of different climatic conditions tolerated by the species.

570. (2.20) In Chapter II, the fact that "many of the species included within the larger genera resemble varieties in being very closely, but unequally, related to each other and in having restricted ranges" serves chiefly

A. to illustrate that the term "genus" designates a natural grouping of organisms as does the term "species."
B. as evidence that the species within a genus were once varieties of a single species.
C. as proof that the terms "genus" and "species" are equivalent.
D. to support the position that natural selection is the major agency in the change of species.
E. as a contrast to the situation in domestic forms, where the greatest variation is found in species whose wild relatives vary but little.

571. (4.30) Chapter II of *Origin of Species* serves chiefly to

A. explain the role played by the process of individual variation in the formation of species by natural selection.
B. list the causes of variation in nature.
C. classify the kinds of variation which occur in nature.
D. clarify the terms used in describing the mechanism of natural selection.
E. argue that groups of species are formed from single earlier species.

572. (4.30) Chapter IV of *Origin of Species* serves chiefly to

A. explain the operation and consequences of natural selection.
B. expound the forces whose result is natural selection.
C. demonstrate that the method of classifying groups within groups in the "natural classification" is an argument for natural selection.
D. enumerate the conditions prerequisite for the operation of natural selection.
E. classify the kinds of variation on which natural selection can act.

573. (2.20) In view of the discussion in Chapter XIV, it would appear that mimicked and mimicking butterflies in one region agree most nearly in

A. external appearance. **B.** numbers.
C. requirements from the environment.
D. ability to escape predators.
E. taxonomic category.

574. (2.30) The criterion which would best reveal which is the mimicking butterfly and which is the mimicked is

A. size of individual butterflies. **B.** numbers.
C. kinds of requirements from the environment.
D. ability to escape predators.
E. external appearance of species most nearly related to each.

575. (2.20) Darwin judges that one species of butterfly has come to mimic another because of

A. a tendency to vary in the same way throughout a group of insects, due to the similar natures of the organisms.
B. greater predation against the non-mimicking than the mimicking members of the species.
C. the direct and definite action of identical conditions of life on similar constitutions.
D. conscious alteration of the colors displayed on the part of the mimicking species.
E. chance.

576. (2.20) Darwin supposes that variations due to either the direct or indirect influence of the environment

A. serve as the raw material for man's selection, but only indirect variations are acted on by natural selection.
B. can be preserved by the selective action of both man and nature.
C. are the basis of man's selection, but definite variations produced by use or disuse are the primary raw material for natural selection.
D. are the basis of natural selection, while definite or indefinite action of the environment are the raw material for selection.

Items 577 - 584.

On the Galapagos Islands in the Pacific, there exist 14 species of finch-like birds with no obvious relatives elsewhere in the world. The islands were pushed up out of the sea by volcanoes more than a million years ago and have never been connected to the mainland. The finches vary from island to island. There is a close resemblance between species in plumage, calls, nests, and eggs but each species differs greatly in beak modifications according to the diet. The members of each species identify each other by the beak. The species do not interbreed and do not compete for food.

After each item number on the answer sheet, blacken space

- **A.** if the statement is true and its truth is supported by the information in the above paragraph.
- **B.** if the statement is true but is not supported by the information in the above paragraph.
- **C.** if the statement is false and shown to be false by the information in the above paragraph.
- **D.** if the statement is false but its falsity is not supported by the information in the above paragraph.

577. (4.20) The different species of finches probably originated from a common ancestor.

578. (4.20) Finches in other parts of the world have plumage, nests, and eggs similar to the Galapagos finches.

579. (4.20) Beak differentiation is one basis for considering the finches as separate species.

580. (4.20) The origin of the various beaks can be traced to sudden climatic changes.

581. (4.20) Isolation is an important factor in the production of new species.

582. (4.20) Fossil records show no evidence of evolution.

583. (6.20) Animals which compete for food may be of different species.

584. (4.20) New species arise through mutations better adapted to environmental conditions.

Items 585 - 586.

In the Nevada desert there is a small pool about 30 feet below the surrounding desert. Here is found a type of fish known as the pupfish which has the smallest range of any known vertebrate and which has existed in this pool since the Ice Age ended.

585. (4.20) The limited range of this species is probably due to

A. hybridization. **B.** natural selection.
C. geographical isolation. **D.** survival of the fittest.

586. (4.20) Change in the anatomy or physiology of this species is

- **A.** impossible because if it were going to change it would have changed by now.
- **B.** possible only if the animal were changed to another habitat.
- **C.** possible only if the animal were crossed with another species.
- **D.** impossible because genes don't change.
- **E.** possible by mutation.

587. (5.00) (Students have read the book *Worlds in Collision* by Velikovsky.) Writing assignment: write a 500-word essay on one of the following:

- **A.** I agree with Velikovsky because:
- **B.** I disagree with Velikovsky because:

26. Classification of Animals and Races of Men

CLASSIFICATION OF ANIMALS AND RACES OF MEN

1. (1.10) Which of the following organisms has the largest number of paired appendages?

A. Octopus. **B.** Crayfish. **C.** Bird.
D. Spider. **E.** Ascaris.

2. (1.10) Which of the following animals takes in oxygen by means of gills?

A. Hydra. **B.** Adult frog. **C.** Turtle.
D. Crayfish. **E.** Whale.

3. (1.10) Which one of the following animals has a sac-like digestive tract?

A. Sea anemone. **B.** Grasshopper. **C.** Clam.
D. Frog. **E.** Starfish.

4. (1.10) Which one of the following animals is segmented?

A. Ascaris. **B.** Clam. **C.** Sea anemone.
D. Starfish. **E.** Grasshopper.

5. (1.10) Four of the following are names of classes of animals. Which one is the name of a phylum?

A. Pisces. **B.** Amphibia. **C.** Crustacea.
D. Mammalia. **E.** Arthropoda.

6. (1.10) Which one of the following phyla has paired appendages?

A. Coelenterata. **B.** Mollusca. **C.** Arthropoda.
D. Echinodermata.
E. Nemathelminthes (round worm).

7. (1.10) Radial symmetry is characteristic of

A. Nemathelminthes. **B.** Coelenterata.
C. Echinodermata. **D.** Two of the above.
E. Three of the above.

8. (1.10) Three-dimensional vision is characteristic of the

A. insects. **B.** fishes. **C.** amphibians.
D. reptiles. **E.** primates.

9. (1.10) The science of animal and plant classification is known as

A. photogeography. **B.** zoogeography.
C. genetics. **D.** taxonomy. **E.** ecology.

10. (1.10) An amphibian is

A. a scaly-skinned animal which employs a diaphragm in breathing.
B. a smooth-skinned animal which undergoes a metamorphosis in its life cycle.
C. an animal which lacks a backbone.
D. an animal which gives birth to living young.
E. an animal which carries its young in a pouch where they undergo further development after birth.

11. (1.10) The body of the hydra has two germ layers known as the

A. protoplasm and cytoplasm.
B. ectoplasm and endoplasm.
C. epidermis and submucosa.
D. ectoderm and endoderm.
E. epithelium and endothelium.

12. (1.10) A student unearthed a human skull in the basement of a home. He observed bony ridges above the eye sockets, 3rd molar teeth and a well developed back part of the skull. From these observations he was able to conclude correctly that the skull belonged to

A. a child.
B. an adult white male.
C. an adult negro male.
D. an adult mongoloid female.
E. an adult white person.

True or False

13. (1.10) The opossum and kangaroo are classified as mammals having true placentae.

Items 14 - 15 deleted.

16. (1.10) Of the following United States snakes the one which is *not* poisonous is the

A. rattlesnake. **B.** bull snake. **C.** coral snake.
D. copperhead. **E.** water moccasin.

True or False.

17. (1.10) Many members of the phylum Platyhelminthes are parasitic.

18. (1.10) Taxonomy is

A. the study of anatomy.
B. the study of disease.
C. the study of structure.
D. the study of classification.
E. none of the above.

19. (1.10) Warm-blooded animals usually have

A. a four-chambered heart.
B. red blood cells.
C. an insulated body covering.
D. an open circulatory system.
E. a long infancy with parental care of the young.

20. (1.10) Biological classification of living organisms is based primarily upon

A. structures having similar origins.
B. structures having similar functions.
C. geographical distribution on the earth.
D. nutritional requirements.
E. use or harm to man.

21. (1.10) The body of coelenterates is made up of two cell layers. These are the

A. epidermis and submucosa.
B. ectoderm and endoderm.
C. ectoplasm and endoplasm.
D. cilia and pseudopodia.
E. protoplasm and cytoplasm.

22. (1.10) A worker bee is

A. a male bee with non-functional sex organs.
B. a male bee capable of fertilizing the eggs.
C. a female bee not capable of producing offspring.
D. an egg-laying female bee.
E. an intersex.

23. How does paramecium ingest food?
(1.10)

A. through the oral groove and gullet.
B. by osmosis through the body wall.
C. by flowing around it.
D. through a protrusile proboscis.

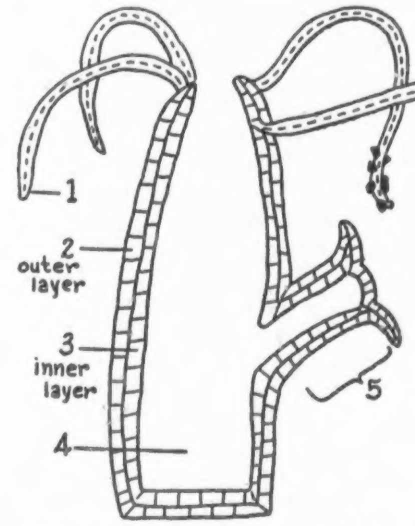
24. The type of symmetry in the crayfish is
(1.10)

A. radial. **B.** biradial. **C.** bilateral.
D. cephalic. **E.** dorsal.

25. In chordates, an elastic rod running lengthwise in the body above the alimentary canal is called a
(1.10)

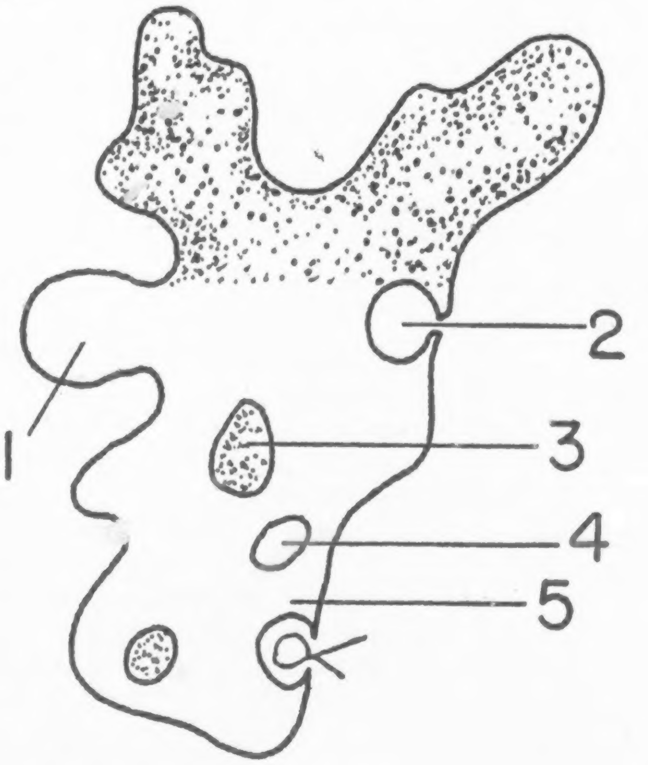
A. backbone. **B.** vertebra. **C.** notochord.
D. spinal cord. **E.** spinal column.

Questions 26 through 28 are based on the diagram of a hydra, on which certain structures are numbered. Identify the structures listed in the questions with those numbered in the diagram.



26. ectoderm. (1.10)
27. bud. (1.10)
28. tentacle. (1.10)

Questions 29 through 32 are based on the diagram of an amoeba, on which certain structures are numbered. Identify the structures listed in the questions with those numbered on the diagram.



29. contractile vacuole. (1.10)
30. pseudopodium. (1.10)

31. nucleus.
(1.10)

32. structure which functions in digestion of food.
(1.10)

33. Capillaries are absent from
(1.10)

A. earthworms (Annelida).
B. marine worms (Annelida).
C. proboscise worms (Nemertea).
D. amphioxus (Chordata). **E.** lamprey (Chordata).

Items 34 - 39.

Cranial capacity (brain size, practically) as measured in cubic centimeters:

A. 450-600. **B.** 700-1050. **C.** 1100-1300.
D. 1400-1600. **E.** 1700-1900.

Which of the above limits include

34. Cro-Magnon man. (1.10)
37. Neanderthal man. (1.10)
35. Gorilla. (1.10)
38. Pithecanthropus. (1.10)
36. Modern man. (1.10)
39. Sianthropus. (1.10)

40. Which of the following would you expect to be most augmented in an obligatory permanent endoparasite?
(1.20)

A. Digestive systems. **B.** Excretory system.
C. Locomotor organs. **D.** Reproductive system.
E. Sense organs.

41. Which is the name of the reproductive polyps of an Obelia colony?
(1.10)

A. Gonangia. **B.** Hydranths. **C.** Medusae.
D. Zooids.

42. Which of the following is considered to be the most recent?
(1.10)

A. Piltdown man. **B.** Heidelberg man.
C. Neanderthal man. **D.** Cro-Magnon man.

43. Which shows an alternation of generations?
(1.10)

A. Crayfish. **B.** Planaria. **C.** Obelia.
D. Earthworm.

44. The extinct dinosaurs are classified as
(1.10)

A. amphibians. **B.** birds. **C.** reptiles.
D. none of these.

45. Which of the following men brought the binomial system of nomenclature into general use?
(1.10)

A. Aristotle. **B.** Linnaeus. **C.** Ray.
D. Wotton.

Items 46 - 50. There are five large groups of protozoa as follows:

A. Mastigophora. **B.** Sarcodina (Rhizopoda).
C. Sporozoa. **D.** Ciliata (Infusoria). **E.** Suctoria.

To which group does each of the following belong?

46. (1.10) Amoeba.

47. (1.10) Paramecium.

48. (1.10) Parasite of amoebic dysentery.

49. (1.10) Parasite of sleeping sickness.

50. (1.10) Parasite of malarial fever.

51 - 55. The groups of Protozoa listed above are separated by their locomotion. Which of the groups have the following methods of locomotion?

51. (1.10) Cilia throughout active life.

52. (1.10) Cilia in young stages; none in adults.

53. (1.10) Flagella.

54. (1.10) Pseudopodia or protoplasmic flow.

55. (1.10) No special locomotion.

Directions: For each of the following organs in a mammal, blacken answer space

A if it is a part of the digestive system.
B if it is a part of the circulatory system.
C if it is a part of the respiratory system.
D if it is a part of the urogenital system.
E if it belongs to *none* of the foregoing systems.

Note: **If an organ has major functions in more than one system, give all the systems to which it belongs.**

56. (1.10) Nephron.

57. (1.10) Lung capillary.

58. (1.10) Glomerulus.

59. (1.10) Gastric glands.

60. (1.10) Duodenum.

61. (1.10) Trachea.

62. (1.10) Aorta.

63. (1.10) Thyroid gland.

64. (1.10) The body plan of the spider is best characterized by

A. head, thorax, and abdomen.
B. head and trunk. **C.** head, trunk, and tail.
D. head-thorax, and abdomen.
E. head, and thorax-abdomen.

65. (1.20) When a fossil adult skeleton is found, by which of the following criteria can it best be determined whether or not the skeleton was probably human?

A. By determining the per cent calcium content of the bones.
B. By determining whether or not the individual was hairy.
C. By measuring the probable height of the individual.
D. By studying the characteristics of the carpals, metacarpals, phalanges, and digits of the forelimbs.
E. By determining the probable brain capacity of the cranium.

66. (1.20) Which of the following characterized the first vertebrates?

A. The nerve cord was located in the ventral region of the body.
B. They had only two embryonic layers—ectoderm and endoderm.
C. The skeleton was made of cartilage.
D. They appeared on the earth in the latter part of the archeozoic era.
E. They lacked segmentation.

67. (1.20) The fact that animals and plants fall into a tree-like system of classification in which the largest branches correspond to the broadest categories while the end twigs correspond to the smallest or narrowest category is explained on the assumption that

A. everybody is familiar with the manner of branching that is characteristic of a tree.
B. organisms are most easily classified on the practical basis of their utility to man.
C. most scientists can read and understand Latin.
D. the species types are now fixed and there are not likely to be any further new categories.
E. organisms have evolved and descended from common ancestors.

68. (1.20) The coelenterates and echinoderms are distinguished from all other major animal phyla studied in the laboratory on the basis of

A. presence or absence of segmentation.
B. location of skeleton—whether internal, external or absent.
C. kind of digestive tract. **D.** kind of symmetry.
E. none of the above.

69. (1.20) The animal phylum to which the frog belongs is distinguished from all other animal phyla by which one of the following characteristics?

A. Kind of digestive tract.
B. Method of obtaining oxygen.
C. Placement of the skeleton.
D. Kind of symmetry.
E. Possession of paired appendages.

70. (1.20) An animal found on the surface of a potato leaf had the following characteristics. It had an exoskeleton and wings. It does not belong to any of the groups listed below. To which group, however, is it most closely related?

A. Aves. **B.** Amphibia. **C.** Crustacea.
D. Annelida. **E.** Mollusca.

71. (1.20) Adaptations separating the vertebrates from the invertebrates include all of these *except*

A. an internal supporting skeleton composed of cartilage or calcified tissues.
B. fin-like appendages for swimming leverage.
C. arrangement of body parts in a wheel-like symmetrical pattern.
D. development of jaws from a transverse mouth.
E. segmented body muscles permitting lateral bending of the body.

72. (1.20) Which one of the following groups of animals has thermostatically-controlled body temperature?

A. Alligators, crocodiles, turtles.
B. Sharks, lungfishes, sturgeons.

C. Seals, porpoises, whales.
D. Salamanders, toads, frogs.
E. Sea urchins, star fishes, sand dollars.

73. (1.20) Free-living Platyhelminthes are similar to the Coelenterates in which one of the following respects?

A. Platyhelminthes have but one opening into the digestive cavity.
B. Platyhelminthes are bilaterally symmetrical.
C. Platyhelminthes have a mesoderm layer.
D. Platyhelminthes have a definite and permanent front end.
E. Platyhelminthes have a dorsal and ventral side.

74. (1.20) The dog, the jackal, and the coyote all belong to the genus Canis. They all belong to different species, however, because

A. while they possess superficial similarities, they are competitors for food in the same ecological community.
B. while they look somewhat alike they are natives of different parts of the world.
C. they were discovered by man over wide intervals of time and were classified into separate categories.
D. they cannot interbreed and produce fertile offspring.
E. the system of classification has been perfected to a point where it is infallible.

75. (1.20) Coelenterates are distinguished from sponges in which one of the following respects?

A. Coelenterates possess two body layers—the ectoderm and the endoderm.
B. Sponges are multicellular organisms.
C. Coelenterates are often sessile.
D. Coelenterates obtain food that is floating in the water.
E. Coelenterates reproduce both sexually and asexually.

76. (1.20) The marked degree of curiosity which is characteristic of monkeys is most closely correlated with

A. their gross stupidity.
B. their tree-dwelling habit.
C. their living in close association with man.
D. their well-developed cerebrum and eyesight.
E. none of the above.

77. (1.20) The sponge is distinguished from all other organisms by the fact that

A. it is unicellular.
B. its principal opening is an exit opening.
C. its single opening serves for both intake of food and discharge of waste.
D. it reproduces both sexually and asexually.
E. it often has radial symmetry.

Items 78 - 86 are concerned with classification of animals. For each item mark

A if the animal belongs to the same phylum as the amoeba.
B if the animal belongs to the same phylum as the coral.
C if the animal belongs to the same phylum as the leech.
D if the animal belongs to the same phylum as the house fly.
E if the animal belongs to the same phylum as the trout.

78. (1.20) Earthworm.

79. (1.20) Malarial parasite.

80. (1.20) Hydra.

81. (1.20) Spider.

82. (1.20) Paramecium.

83. (1.20) Monkey.

84. (1.20) Jelly fish.

85. (1.20) Dinosaur.

86. (1.20) Lobster.

For items 87 - 89 select from the key the animal group in which each of the characteristics listed made its first evolutionary appearance.

KEY

A. Annelid worms. B. Sharks. C. Bony fishes.
D. Sponges. E. Amphibians.

87. (1.20) Paired lungs.

88. (1.20) Protective, digestive, and sensitive tissues.

89. (1.20) Movable jaws.

90. (1.20) All cold-blooded animals

A. are below birds on the evolutionary scale.
B. maintain a body temperature a few degrees below that of man.
C. can remain alive but inactive at practically any temperature.
D. have basic metabolism rates higher than warm blooded animals.
E. will die if their body temperature goes below the temperature at which water freezes.

91. (1.20) Whales are quite commonly considered to be fish. Biologists consider them mammals. The best explanation of this discrepancy involves the fact that people in general are more apt to rely for their concepts on

A. environmental coincidences.
B. structural similarities. C. species relationships.
D. authorities. E. anatomical comparisons.

92. (1.20) Which of the following characteristics is shared by all insects?

A. Asexual reproduction.
B. Complete metamorphosis.
C. Circulatory system with oxygen being carried by the blood.
D. Jointed appendages.
E. Either one or two pairs of wings.

93. (1.20) A characteristic separating man from all other primates is

A. the opposable thumb.
B. the ability to see a single image with both eyes open.
C. a projecting chin.
D. larger and better developed teeth.
E. a less prominent nose.

94. Gases used in photosynthesis enter and leave the plant
(1.20) primarily through the

A. cambium. **B.** phloem. **C.** stomates.
D. parenchyma cells. **E.** pith rays.

95. Which *one* of the following animals is *not* a mammal?
(1.20)

A. Bat. **B.** Monkey. **C.** Alligator.
D. Mouse. **E.** Whale.

96. Corals belong to the phylum designated as
(1.20)

A. Echinoderms. **B.** Molluscs. **C.** Arthropods.
D. Chordates. **E.** Coelenterates.

97. The distinguishing characteristic of the marsupials is
(1.20) the possession of a

A. scaly tail. **B.** pouch. **C.** diaphragm.
D. fur-covered body. **E.** four-chambered heart.

For items 98 - 101 mark space

A if the animals described are *Crustaceans.*
B if the animals described are *Insects.*
C if the animals described are *Arachnids.*
D if the animals described are *Myriapods.*
E if the animals described belong to none of the above categories.

98. This group has three pairs of legs, one pair of antennae
(1.20) and varies from winglessness to two pairs of wings.

99. These animals have four pairs of legs, no antennae and
(1.20) no wings.

100. Members of this group possess five pairs of walking
(1.20) legs, two pairs of antennae and no wings.

101. This constitutes the most abundant and widespread
(1.20) group of all land animals.

102. The distinguishing characteristic of chordates is
(1.20)

A. a ventrally placed nerve cord.
B. a water vascular system.
C. a chitinous body covering.
D. an elastic rod which is the forerunner of the backbone.
E. an open circulatory system.

103. Which of the following is a non-placental mammal?
(1.20)

A. Man. **B.** Spider monkey. **C.** Mouse.
D. Duck-billed platypus. **E.** Fox.

104. Which of the following insects has chewing mouth
(1.20) parts?

A. grasshopper. **B.** plant louse. **C.** mosquito.
D. cabbage butterfly. **E.** squash bug.

105. Amphibia may be characterized by
(1.20)

A. the possession of a scaly skin.
B. having a four-chambered heart.
C. being the first organisms to evolve the land egg.
D. being cold-blooded organisms during the first life-stage, followed by the warm-blooded adult stage.
E. gill, lung, and cutaneous respiration during the life cycle.

106. A house fly has mouthparts that are
(1.20)

A. vestigial. **B.** of the sucking type.
C. of the piercing and sucking type.
D. of the chewing type.
E. of the chewing and sucking type.

107. A characteristic separating man from all other primates
(1.20) is

A. the opposable thumb.
B. exhibition of curiosity.
C. stereoscopic vision allowing for space perception.
D. degenerate sense of smell.
E. a projecting chin.

108. All *except* which *one* of the following are insects?
(1.20)

A. Dragon fly. **B.** Centipede. **C.** Firefly.
D. Treehopper. **E.** Body louse.

109. Which one of the following animals is classified as a
(1.20) reptile?

A. Whale. **B.** Toad. **C.** Turtle.
D. Salamander. **E.** Eel.

110. Of the following the one distinguishing characteristic of
(1.20) all vertebrates is the possession of

A. an internal body skeleton.
B. a hairy body covering.
C. mammary glands to nourish the young.
D. a circulatory system. **E.** a nervous system.

111. Man is similar to the apes in that both man and the
(1.20) apes possess

A. a well developed forehead.
B. reduced brow ridges.
C. a great toe opposable to the other toes.
D. a thumb opposable to the other fingers.
E. small canine teeth.

112. Ordinarily more resemblance exists among members of
(1.20) a class than among the members of

A. a phylum. **B.** a family. **C.** a genus.
D. a species. **E.** an order.

For items 113 - 119 select from the key the most appropriate or closely related phrase.

A. Characteristic of mammals only.
B. Characteristic of mammals and birds.
C. Characteristic of birds and reptiles.
D. Characteristic of reptiles and amphibians.
E. Characteristic of amphibians and fish.

113. Possess non-nucleated red corpuscles.
(1.20)

114. Are warm blooded.
(1.20)

115. Respire by gills in some stage of development.
(1.20)

116. Eggs minute, without shells and retained in uterus of
(1.20) female for development.

117. Skin moist or with mucous glands.
(1.20)

118. Possess a completely four-chambered heart and either
(1.20) nucleated or non-nucleated corpuscles.

119. (1.20) Possess a functional allantois.

120. (1.20) The difference in skin color between an American Indian and an American Negro is a

A. species difference. **B.** genus difference.
C. family difference.
D. smaller difference than that between a wolf and fox.
E. larger difference than that between a dog and a wolf.

121. (1.20) An amphibian is

A. a reptile. **B.** a cold-blooded vertebrate.
C. an invertebrate. **D.** a mammal.
E. a marsupial.

For each of the following items, mark space

A if the description refers to the Negroid race.
B if the description refers to the Australoid race.
C if the description refers to the Mediterranean race.
D if the description refers to the Alpine race.
E if the description refers to the Mongoloid race.

122. (1.20)
Kind of hair: wavy.
Shape of head: long.
Shape of nose: narrow.
Complexion: light and brown.

123. (1.20)
Kind of hair: wavy, light brown to black.
Shape of head: short and broad.
Complexion: light to brown.

124. (1.20)
Kind of hair: straight, stiff, black.
Shape of head: broad.
Complexion: yellow or red.

125. (1.20)
Kind of hair: wavy.
Shape of head: long.
Shape of nose: flat.
Complexion: dark.
Body: hairy.

126. (1.20)
Kind of hair: wooly or kinky.
Shape of head: long.
Shape of nose: flat.
Complexion: dark.

127. (1.20) The races of living man today

A. are three in number based on color.
B. are all of the same species, Homo sapiens.
C. can be classified into seven species.
D. are not all known as yet.
E. are clearly distinguished from one another.

128. (1.20) Man is classified as a vertebrate because he

A. is the most intelligent animal.
B. looks like other vertebrates in early life.
C. walks erect. **D.** has mammary glands.
E. has a spinal column.

Items 129 - 145.

Blacken the space corresponding to the lowest or simplest organism in the list which possesses the structure, organ, system or other characteristic.

A. Ameba. **B.** Hydra. **C.** Planaria.
D. Earthworm. **E.** Man.

129. (1.20) Body cavity.

130. (1.20) Gastrovascular cavity.

131. (1.20) Food vacuole.

132. (1.20) Enzymes produced in the protoplasm.

133. (1.20) Digestive cavity with a single opening.

134. (1.20) Mesoderm.

135. (1.20) Extracellular digestion only.

136. (1.20) A coiled digestive tube.

137. (1.20) Bilateral symmetry.

138. (1.20) Intracellular digestion only.

139. (1.20) Intracellular and extracellular digestion.

140. (1.20) Absorbed foods carried away in blood vessels.

141. (1.20) A muscular pharynx leading to the esophagus.

142. (1.20) Peritoneum.

143. (1.20) Anus.

144. (1.20) Asymmetry.

145. (1.20) No special opening for elimination of undigested food.

146. (1.20) The degree to which organs correspond in regard to origin and structure in different kinds of living things, irrespective of function, is *most* directly useful in

A. preparation of animals for blood transfusion.
B. selection of mates in breeding experiments.
C. choice of organisms to be used in stocking a pool.
D. taxonomic classification.
E. explaining the high degree of toleration developed in some instances between host and parasite.

147. (1.20) Which of the following animals develop a placenta?

A. Fishes. **B.** Reptiles. **C.** Amphibians.
D. Monotremes. **E.** None of these.

Items 148 - 172.

The following categories are in order of decreasing extent of application. After each item number on the answer sheet blacken the *one* lettered space which designates the category to which the item applies.

A All living organisms.
B Most plants and animals. (The great majority but not all of *both*.)
C Most plants or most animals. (The great majority but not all of *either*.)
D A group of plants *or* animals comparable to a single phylum or an important sub-phylum.
E A group of plants or animals smaller than any of the preceding groupings, more specifically, a single class of *either*.

148. (1.20) The possession of chlorophyll.

149. (1.20) The process of respiration.

150. (1.20) The possession of supporting tissue of some degree of differentiation.

151. (1.20) Reproduction by means of flowers.

152. (1.20) The possession of cellulose cell walls.

153. (1.20) The possession of a system of some degree of complexity for transporting materials within the bodies of organisms.

154. (1.20) The transformation of lifeless food into living protoplasm.

155. (1.20) Reproduction by means of seeds.

156. (1.20) The possession of a metabolism.

157. (1.20) The formation of germ layers in the process of development.

158. (1.20) The possession of a multicellular body.

159. (1.20) The possession of bilateral symmetry.

160. (1.20) The elimination of wastes.

161. (1.20) The possession of feathers.

162. (1.20) The production of spores which function in some way in the process of reproduction.

163. (1.20) The possession of a protective covering tissue.

164. (1.20) The possession of vertebrae.

165. (1.20) The possession of a chitinous exoskeleton.

166. (1.20) The possession of mammary glands.

167. (1.20) The quality of being sensitive to environmental influences.

168. (1.20) Reproduction by sexual methods.

169. (1.20) The occurrence of diffusion in some part of the organism.

170. (1.20) Some differentiation of nervous tissue.

171. (1.20) The embryonic young are nourished by means of a placenta.

172. (1.20) The possession of a sporophyte and gametophyte generation in the life cycle.

173. (1.20) The coelenterates (hydra, etc.) and echinoderms (starfish, etc.) are distinguished from all other major animal phyla studied in the laboratory on the basis of

A. presence or absence of segmentation.
B. location of skeleton—whether internal, external, or absent.
C. kind of digestive tract. **D.** kind of symmetry.
E. none of the above.

174. (1.20) The animal phylum to which the frog belongs is distinguished from all other animal phyla by which one of the following characteristics?

A. Kind of digestive tract.
B. Structure of respiratory system.
C. Location of its skeleton. **D.** Kind of symmetry.
E. Possession of paired appendages.

175. (1.20) The frog and the cat both have all *except* which one of the following structures?

A. Gall bladder. **B.** Cloaca. **C.** Pancreas.
D. Anus. **E.** Pharynx.

176. (1.20) Four of the following are names of classes of animals. Which one is the name of a phylum?

A. Pisces. **B.** Amphibia. **C.** Crustacea.
D. Mammalia. **E.** Arthropoda.

177. (1.20) *Euglena viridus* is a single-celled aquatic organism which possesses chlorophyll but has no cell wall. It carries on photosynthesis but it has a mouth and swims about by means of a flagellum. It could reasonably be classified as

A. a protozoan. **B.** a chlorophyte.
C. a mycophyte. **D.** two of the above.
E. all of the above.

178. (1.20) *Euglena viridis* is a single-celled aquatic organism which possesses chlorophyll but has no cell wall. It would reasonably be placed amongst

A. the Protozoans. **B.** the Algae. **C.** the Fungi.
D. two of the above. **E.** all of the above.

179. (1.20) Which one of the following phyla has paired appendages?

A. Coelenterata. **B.** Mollusca. **C.** Arthropoda.
D. Echinodermata.
E. Nemathelminthes (round worm).

Items 180 and 181 are based on the following key.

KEY

A. Birds and bats. **B.** Spiders and mosquitoes.
C. Flatworms and roundworms.
D. Human beings and pigs. **E.** Fish and whales.

180. (1.20) According to our classification system of animals, in which of the above pairs of animals is there the closest relationship?

181. (1.20) According to our classification system of animals, in which of the above pairs of animals is there the least relationship?

182. (1.20) A plant which has roots, stems, and leaves, and bears seeds but not flowers could be a

A. fern plant. **B.** spruce tree. **C.** moss plant.
D. maple tree. **E.** wheat plant.

183. (1.20) In the following pair, blacken space 1 if the first element of the pair is definitely greater than the second; space 2 if the second is definitely greater than the first; and space 3 if the two are approximately equal.

A. Number of plant phyla.
B. Number of animal phyla.

Items 184 - 191.

For each of the items mark the number from the following list which indicates the narrowest or smallest category of classification which includes both elements. Base your decision on laboratory work, general knowledge, and reasoning ability.

A. Kingdom. **B.** Phylum. **C.** Class.
D. Genus. **E.** Species.

184. (1.20) Bat and bird.

185. (1.20) Earthworm and tapeworm.

186. (1.20) Hookworm and tapeworm.

187. (1.20) Song sparrow and field sparrow.

188. (1.20) Black rat and Norway rat.

189. (1.20) Whale and fish.

190. (1.20) *Drosera rotundifolia* in New York State and *Drosera rotundifolia* in Massachusetts.

191. (1.20) Whale and pig.

192. (1.20) Which one of the following is the only basis for a scientific classification of races?

A. The language they speak
B. The culture they have developed.
C. The mental characteristics they possess.
D. The physical characteristics they possess.
E. The geographical area in which they live.

193. (1.20) Present-day man would find closest resemblance to himself and his own manner of living in

A. Piltdown man. **B.** Cro-Magnon man.
C. Peking man. **D.** Java man. **E.** Heidelberg man.

194. (1.20) The scientific name of man is *Homo sapiens*. The term *Homo* represents which of the following?

A. Order. **B.** Class. **C.** Phylum. **D.** Species.
E. Genus.

195. (1.20) Which one of the following belongs to a different phylum from the other four?

A. Flying squirrel. **B.** Bat. **C.** Robin.
D. Flying fish. **E.** Fly.

196. (1.20) Of the following, the one distinguishing characteristic of all vertebrates is the possession of

A. an internal body skeleton.
B. a hairy body covering
C. mammary glands to nourish the young.
D. a circulatory system. **E.** a nervous system.

197. (1.20) Present-day man belongs to the same species as

A. the anthropoid apes.
B. the fossil known as Java man.
C. his presumed common ancestor and that of the apes.
D. the primates. **E.** no other kind of living organism.

198. (1.20) All except which one of the following are insects?

A. Mud-dauber wasp. **B.** Clothes moth.
C. Dragon fly. **D.** Black widow spider.
E. Dog flea.

199. (1.20) The dinosaurs are classified as

A. primates **B.** ungulates. **C.** mammals.
D. reptiles. **E.** invertebrates.

For items 200 - 203 select from the key the animal form which appeared contemporaneously with the plant forms mentioned in the item, then mark the corresponding answer space.

A. Shell fish. **B.** Mammals (other than man).
C. Reptiles. **D.** Amphibians. **E.** Man.

200. (1.20) Algae.

201. (1.20) Conifers and cycads.

202. (1.20) Seed ferns of dense forests making coal measures of Pennsylvania.

203. (1.20) Flowering plants.

In item 204, a structural or functional condition is to be compared with other conditions below it. Blacken the answer space corresponding to the number of the *one* condition which most closely resembles the first stated condition.

204. (1.20) The shape of an ameba.

A. The shape of a paramecium.
B. The shape of a human red blood cell.
C. The shape of a human white blood cell.

For items 205 - 209 select from the key the name of the structure or mechanism used in the exchange of gases in the organism named in each item.

A. Lungs. **B.** Gills. **C.** Cell-to-cell diffusion.
D. Two of the above. **E.** All of the above.

205. (1.20) Adult frog.

206. (1.20) Tadpole.

207. (1.20) Frog egg at the 16-cell stage.

208. (1.20) Adult human being.

209. (1.20) Human fetus.

210. (1.20) Man is classified in the order

A. Carnivora, the flesh eaters.
B. Primates, the climbing mammals.
C. Marsupialia, the pouched mammals.
D. Rodentia, the gnawers.

211. (1.20) Which is the broadest classification?

A. Class. **B.** Family. **C.** Genus. **D.** Phylum.
E. Species.

212. (1.20) The relationship among the animal phyla is best represented by

A. a single linear series from the simple to the complex.
B. a branching, treelike arrangement from a central axis.
C. a circular arrangement for each of the main types.
D. a series of separate compartments into which all animals can be classified.

Questions 213 thru 220 deal with characteristics of animals as related to the phylum to which the animals belong. Indicate the phylum to which animals possessing each characteristic belong by marking

A for Arthropoda. **B** for Chordata.
C for Echinodermata. **D** for Platyhelminthes.
E for Protozoa.

213. (1.20) Single-celled animals.

214. (1.20) Radially symmetrical.

215. (1.20) Flame cells, excretory tubules.

216. (1.20) Spiny exoskeleton of calcareous plates.

217. (1.20) Chitinous exoskeleton.

218. (1.20) Gill slits and notochord present in some stage of life history.

219. (1.20) Body-dorso-ventrally flattened; leaf-like.

220. (1.20) Locomotion by means of cilia, pseudopodia, or flagella.

Items 221 - 229 are concerned with classification of animals. For each item mark space

A if the animal belongs to the same phylum as the amoeba.
B if the animal belongs to the same phylum as the coral.
C if the animal belongs to the same phylum as the leech.
D if the animal belongs to the same phylum as the house fly.
E if the animal belongs to the same phylum as the trout.

221. (1.20) Earthworm.

222. (1.20) Malarial parasite.

223. (1.20) Hydra.

224. (1.20) Spider.

225. (1.20) Paramecium.

226. (1.20) Man.

227. (1.20) Jelly fish.

228. (1.20) Whale.

229. (1.20) Lobster.

230. (1.20) A spider differs from an insect in that the spider

A. lacks locomotor appendages on the abdomen.
B. has eight legs. **C.** has a hard external skeleton.
D. reproduces by internal fertilization.
E. none of the above are differentiating features.

231. (1.20) The animal which does not belong to the same class as the others is

A. frog. **B.** salamander. **C.** toad. **D.** newt.
E. turtle.

232. (1.20) The animal form immediately following the amphibian in evolution is the

A. reptile. **B.** fish. **C.** bird. **D.** mammal.
E. shellfish.

233. (1.20) Which of the following is a mollusc?

A. Sponge. **B.** Jellyfish. **C.** Snail. **D.** Crab.
E. Leech.

234. (1.20) An animal belonging to the class Amphibia would not have

A. scales. **B.** lungs. **C.** gills. **D.** a backbone.
E. a smooth skin.

235. (1.20) A plant having true roots, stems, leaves and a vascular system but which is non-seed-bearing would likely be

A. a fern. **B.** a moss. **C.** an alga.
D. an evergreen tree. **E.** a deciduous tree.

236. (1.20) The skeletons of man, ape, bird, and frog have four of the following characteristics in common. In which one do they differ?

A. Number of digits on forelimb.
B. Possession of a femur.
C. Possession of a pelvic girdle.
D. Possession of a pectoral girdle.
E. Number of bones in the upper hind limb.

237. (1.20) Which of the following skeletal types resemble each other most closely?

A. Man and frog. **B.** Ape and frog.
C. Man and ape. **D.** Cat and frog.
E. Man and cat.

238. (1.20) Which statement contains structures that are not homologous?

A. The arm of man and the foreleg of a horse.
B. The flipper of a whale and the wing of a bat.
C. The wing of a bird and the forelimb of an ape.
D. The wing of a butterfly and the wing of a bird.
E. The hind leg of a cat and the leg of a man.

239. (1.20) Of the following animals which one was probably the earliest arrival (i.e., the oldest) on the earth?

A. Flatworm. **B.** Annelida. **C.** Coelenterate.
D. Arthropod. **E.** Roundworm.

240. (1.20) In the evolutionary sequence, which of the above (item 239) was probably the latest (i.e. the most recent) arrival on the earth?

241. (1.20) One of the following is improperly associated with the other four organisms in the list. Which one is it?

A. Whale. **B.** Frog. **C.** Turtle. **D.** Perch.
E. Crayfish.

For items 242 - 245 use the following key.

KEY

A. Kingdom. **B.** Phylum. **C.** Class. **D.** Genus.
E. Species.

242. (1.20) The scientific name of the dandelion is *Taraxacum officinale*. In which of the five key categories would *Taraxacum* fall?

243. (1.20) What is the smallest category in the above key that would include all plants which have true roots, stems and leaves but which do not produce seeds?

244. (1.20) What is the smallest key category that would include all plants which produce seed having but one cotyledon?

245. (1.20) What is the smallest key category that would include all plants which have a vascular system?

246. (1.20) Which characteristic below is not possessed by at least some present-day member of each of the three classes, Reptiles, Aves, and Mammalia?

- **A.** Teeth in sockets.
- **B.** A tubular nerve cord dorsal to the alimentary tract.
- **C.** Oviparous. **D.** Scales.
- **E.** Closed circulatory system.

247. (1.20) There is living on the earth at the present time only one species of

A. ape. **B.** bear. **C.** monkey. **D.** dinosaur.
E. man.

Items 248 - 262.

After each item number on the answer sheet, blacken space

- **A** if the item is true for fishes and amphibians.
- **B** if the item is true for reptiles, birds, and egg laying mammals.
- **C** if the item is true for placental mammals.
- **D** if the item is true for more than one of the above categories.
- **E** if the item is not true for any of the above categories.

248. (1.20) Fertilization is internal in the oviduct.

249. (1.20) Fertilization is external in the water.

250. (1.20) The embryo forms an allantois which functions for respiration and excretion.

251. (1.20) These embryos form yolk sacs.

252. (1.20) Egg has a shell for protection.

253. (1.20) An embryo of this group develops in the uterus.

254. (1.20) Develop an amnion and chorion.

255. (1.20) Eggs are produced by the ovary of the female.

256. (1.20) In some of these forms, external fertilization of the eggs is insured by the clasping habit.

257. (1.20) Development of the embryo takes place in the water.

258. (1.20) There are only two embryonic germ layers.

259. (1.20) In some of these forms, a hormonal mechanism regulates the menstrual cycle.

260. (1.20) In some of these forms, external fertilization is insured by the building of a nest for depositing eggs and sperms.

261. (1.20) Produce eggs with large, inert yolk masses which do not divide.

262. (1.20) Developing young receive nourishment from the blood of the mother.

Items 263 - 279.

KEY

- **A.** if the item applies to mammals.
- **B.** if the item applies to birds.
- **C.** if the item applies to reptiles.
- **D.** if the item applies to more than one of the preceding groups of animals.
- **E.** if the item does not apply to any of the preceding groups of animals.

263. (1.20) Fertilization is generally external.

264. (1.20) Only a very small number of the group lay eggs.

265. (1.20) They were the dominant group of animals during the Mesozoic era.

266. (1.20) They have no teeth.

267. (1.20) The yolk of the egg contains all of the food necessary for development of the embryo.

268. (1.20) Man belongs to this group.

269. (1.20) Frogs are members of this group.

270. (1.20) The young develop within an amnion.

271. (1.20) In most forms the young are born alive.

272. (1.20) They are cold blooded.

273. (1.20) Chickens belong to this group.

274. (1.20) They are without paired appendages.

275. (1.20) Pigeons belong to this group.

276. (1.20) They became the first really successful land animals.

277. (1.20) They have teeth.

278. (1.20) The horned toad, one of the lizards, is a member of this group.

279. (1.20) The allantois functions as a respiratory and excretory organ.

280. (1.20) Structures appearing in birds, along with the evolution of "warm-bloodedness," which helps make "warm-bloodedness" possible are

- **A.** feathers. **B.** red blood cells.
- **C.** the components of the completely four-chambered heart.
- **D.** wings.

Items 281 - 286. After each exercise on the answer sheet, blacken the *one* lettered space which designates the organism which possesses the given characteristic or characteristics at some time during its life history.

281. (1.20) Possesses cellulose cell walls, nucleated cells, *but not* chlorophyll.

A. Amoeba. B. Alga. C. Flowering plant.
D. Hydra. E. Bread mold.

282. (1.20) Possesses placenta, internal fertilization, but non-functional yolk sac.

A. Man. B. Bird. C. Alligator.
D. Duckbill platypus. E. Toad.

283. (1.20) Possesses functional yolk sac, external fertilization and development, but not extra-embryonic membranes.

A. Fish. B. Reptile. C. Bird.
D. Primitive mammal (duckbill platypus).
E. Advanced mammal.

284. (1.20) Possesses two germ layers, stinging cells, but not separate digestive tract or circulatory system.

A. Sponge. B. Hydra. C. Flatworm.
D. Earthworm. E. Starfish.

285. (1.20) Possesses notochord, gill slits, a nerve cord dorsal to the alimentary canal, but not vertebrae.

A. Amphioxus (prechordate). B. Fish.
C. Amphibian. D. Reptile. E. Mammal,

286. (1.20) Possesses vertebrae, completely 4-chambered heart, and flat nails on digits

A. Reptile. B. Bird. C. Rodent. D. Monkey
E. Kangaroo

Items 287 - 290.

After each exercise on the answer sheet, blacken the *one* lettered space which designates the organism which possesses the given characteristic or characteristics at some time during its life history.

287. (1.20) Possesses notochord *but not* vertebrae.

A. Starfish. B. Squid. C. Amphioxus.
D. Eel. E. Frog.

288. (1.20) Possesses vertebrae, lungs, paired appendages, *but not* amnion and allantois.

A. Perch. B. Frog. C. Bird. D. Turtle.
E. Man.

289. (1.20) Possesses mesodern *but not* coelom.

A. Flatworm. B. Coelenterate. C. Roundworm.
D. Starfish. E. Annelid.

290. (1.20) Possesses cellulose cell walls, nucleated cells, but not chlorophyll.

A. Amoeba. B. Alga. C. Flowering plant.
D. Hydra. E. Bread mold.

291. (1.20) Which one of the following fossil men resembled most closely present-day man?

A. Heidelberg man. B. Piltdown man.
C. Peking man. D. Java man.
E. Cro-Magnon man.

292. (1.20) Which one of the following includes all the others?

A. Order. B. Species. C. Class. D. Family.
E. Genus.

293. (1.20) Which is found in Gonionemus but not in hydra?

A. Basal disc. B. Hypostome. C. Tentacles.
D. Radial canal.

Items 294 - 298

Some of the anatomical structures and arrangements of a mammal are peculiar to mammals, while others are found also in some or all of the other vertebrate classes.

Directions: For each of the following descriptions of structural arrangements, *blacken* answer space

- **A** if it is found in mammals, but not amphibia nor fishes.
- **B** if it is found in mammals and amphibia but not in fishes.
- **C** if it is found in mammals, amphibia, and fishes.
- **D** if it is *not* found in mammals.

294. (1.20) A hollow central nervous system runs lengthwise in the dorsal part of the animal.

295. (1.20) The heart consists of two auricles and two ventricles.

296. (1.20) The external surface of the body is protected by hair.

297. (1.20) Locomotion is accomplished at least in part by two pairs of limbs.

298. (1.20) The heart has two auricles.

299. (1.20) Which of the following do not apply to vertebrates?

A. Jointed skeleton. B. Vertebra.
C. Ventrally located spinal cord.
D. Tubular alimentary canal.

300. (1.20) Common bread mold (Rhizopus), is a (an)

A. Myxomycete. B. Phycomycete.
C. Ascomycete. D. Basidiomycete.
E. Deuteromycete.

Items 301 - 306. Representatives of the following groups have been studied in the laboratory:

A. Annelida. B. Cestoda. C. Coelenterata.
D. Traemetoda. E. Turbellaria.

To which of the groups do each of these animals belong?

301. (1.20) Dugesia.

302. (1.20) Nereis.

303. (1.20) Obelia.

304. (1.20) Pelmatohydra.

305. (1.20) Prosthogonimus.

306. (1.20) Taenia.

307. (1.20) Which of the following is found in both hydra and earthworm?

A. Endoderm. B. Metemeres. C. Coelom.
D. Radial symmetry.

308 - 311. There are four large groups of Protozoa as follows:

A. Mastigophora. B. Sarcodina (Rhizopoda).
C. Sporozoa. D. Ciliophora (Infusoria).

To which of the four groups does each of the following belong?

308. Amoeba.
(1.20)

309. Parasite of African sleeping sickness.
(1.20)

310. Parasite of amebic dysentery.
(1.20)

311. Paramecium.
(1.20)

312. Archaeopteryx is said to have been a
(1.20)

A. bird. **B.** reptile. **C.** mammal.
D. amphibian.

313. Which animal belongs to the Phylum Protozoa, Class Hydrozoa?
(1.20)

A. Amoeba. **B.** Hydra. **C.** Obelia.
D. None of these.

314. Planaria is considered a "higher" animal than hydra because
(1.20)

A. it has a mouth. **B.** it is bilaterally symmetrical.
C. it has an enteron. **D.** it reproduces sexually.

315. Which of the following are in the proper order?
(1.20)

A. Protozoa, Sarcodina, Amoebidae, Amoebida, Amoeba.
B. Protozoa, Sarcodina, Amoeba, Amoebida, Amoebidae.
C. Protozoa, Sarcodina, Amoeba, Amoebidae, Amoebida.
D. Protozoa, Sarcodina, Amoebida, Amoebidae, Amoeba.
E. Sarcodina, Protozoa, Amoebida, Amoebidae, Amoeba.

316. In which of the following lists of the categories used in classification are the categories in their proper position?
(1.20)

A. Phylum, class, family, order, genus.
B. Phylum, class, order, family, genus.
C. Phylum, family, order, class, genus
D. Phylum, order, class, family, genus.
E. Order, phylum, family, class, genus.

317 - 324. These questions are based on the key list below. Select from it the term most clearly indicated in each item.

KEY

A. Heidelberg. **B.** Peking. **C.** Swanscombe.
D. Java. **E.** Neanderthal.

317. The earliest Neanderthaloid.
(1.20)

318. *Homo sapiens.*
(1.20)

319. Contemporaneous with, but more primitive than, *Homo sapiens.*
(1.20)

320. The oldest known fossil man.
(1.20)

321. The best-known of the pre-*sapiens* human fossils.
(1.20)

322. Skull thin-boned, without heavy brow ridges; from great interglacial.
(1.20)

323. Which of the above was most closely related to Cro-Magnon?
(1.20)

324. A five-foot-three-inch stock of brutish men still living during the fourth glacial.
(1.20)

325 - 331. From the key list below, select the term to which each of the following most clearly applies.

KEY

A. Ainu. **B.** Negroid. **C.** Mongoloid.
D. Melanesian. **E.** Caucasoid.

325. The "white European" stock.
(1.20)

326. The most geographically-restricted stock.
(1.20)

327. The group that includes the Eskimo.
(1.20)

328. The group that includes the Mediterraneon people.
(1.20)

329. Longheaded people with peppercorn hair (among others).
(1.20)

330. Distributed from New Guinea to Fiji.
(1.20)

331. Hiawatha.
(1.20)

332. That portion of the human skeleton which surrounds the brain and spinal cord belongs to
(1.20)

A. the appendicular skeleton. **B.** the axial skeleton.
C. the pectoral girdle. **D.** the pelvic girdle.
E. the coccyx.

333. Which of the following groups of bones belongs entirely to the appendicular skeleton?
(1.20)

A. skull, vertebral column, ribs, sternum.
B. vertebral column and pelvic girdle.
C. vertebral column, ribs, sternum, clavicle.
D. sacrum, pelvic girdle, and femur.
E. carpals, tarsals, phalanges.

334. The clavicle is a bone in the
(1.20)

A. cranium. **B.** lower jaw. **C.** skull.
D. axial skeleton. **E.** appendicular skeleton.

Items 334 - 344. The following animals are listed without regard for degree of complexity.

A. Ascaris: roundworm. **B.** Cambarus: crayfish.
C. Dugesia: planarian. **D.** Lumbricus: earthworm.
E. Pelmatohydra: hydra.

Characteristics listed below appear in one or more of the animals. Check the simplest animal in which each characteristic is found.

335. Bilateral symmetry.
(1.20)

336. Space present between the body cell and the alimentary canal.
(1.20)

337. Circulatory system.
(1.20)

338. Division of labor among cells.
(1.20)

339. Exoskeleton.
(1.20)

340. Jointed legs.
(1.20)

341. Mesoderm.
(1.20)

342. Metamerism.
(1.20)

343. Mouth and anus.
(1.20)

344. Multicellular.
(1.20)

345. (1.20) Animals that belong to the same class also belong to the same

A. family. **B.** genus. **C.** species. **D.** phylum. **E.** order.

Items 346 - 355. Key list:

A. Present in Amoeba. **B.** Present in Parmaceum.
C. Present in both. **D.** Present in neither.

346. (1.20) Contractile vacuole.

347. (1.20) Ectoplasm.

348. (1.20) Endoplasm.

349. (1.20) Flagella.

350. (1.20) Food vacuoles.

351. (1.20) Mouth.

352. (1.20) Oral groove.

353. (1.20) Pseudopodia.

354. (1.20) Separate macro- and micronucleus.

355. (1.20) Trichocysts.

Items 356 - 360 refer to the following description of a fossil organism found preserved in the rocks. The organism possessed

A. a backbone.
B. a long tail, flattened horizontally at the end.
C. four limbs of approximately equal length and size.
D. a body with neither hair nor feathers; its skin was probably not slimy.
E. a "little" finger of the fore limbs greatly extended several times the length of the body.
F. a broad weblike membrane extending between the long "little" finger of the fore limbs and the hind legs, and between the hind legs and the tail. The membrane was in appearance somewhat like the wing of a bat.
G. bones of the skeleton hollow and light.
H. digits, other than the "little" finger of the fore limbs, equipped with claws.
I. sharp slender teeth, all alike, lining the jaw.
J. the organism probably laid land eggs.
K. Other fossil associates were dinosaurs and certain amphibians.

356. (2.20) The organism was

A. a bird. **B.** a mammal. **C.** a reptile.
D. an amphibian. **E.** a fish.

357. (2.20) The organism's chief means of locomotion was by

A. walking. **B.** flying. **C.** crawling.
D. jumping. **E.** swimming.

358. (2.20) The organism was probably

A. warm blooded. **B.** cold blooded.
C. warm blooded during part of its development.
D. bloodless (like the hydra).

359. (2.20) The animal probably lived in

A. an arctic climate. **B.** a subarctic climate.
C. a temperate climate (such as Michigan).
D. a subtropical climate (such as Florida).
E. a desert (such as Arizona).

360. (2.20) Its teeth were adapted to

A. grazing (like those of the horse).
B. browsing (eating leaves and twigs like the deer or giraffe).
C. gnawing (like the rat's).
D. insect eating (like those of the moles, shrews, and hedgehogs).
E. stabbing (like those of the walrus and seal).

361. (2.20) Which of the following describes best what a geneticist means when he speaks of races?

A. Races are populations within a species that differ in the frequencies of some genes.
B. Races are populations within a species in which all members are genetically identical.
C. Races are populations within a species in which interbreeding is not physiologically possible.
D. Races are populations within a species that are culturally distinct.
E. Races are populations within a species which when intercrossed with another species produce offspring that are poorly viable.

362. (3.00) There are two different fossil forms, each representing different phyla, found in the undisturbed rock layers of a cliff. One of these is the early amphibian, *Onychopus*. It is found in a rock layer near the top of the cliff. The other form found in the rock layers below the amphibian is

A. a dinosaur. **B.** a primitive dog.
C. the primitive bird, *Archeopteryx*. **D.** a snake.
E. a fish.

Certain aspects of the structural arrangements within a mammal are especially important in adapting the mammal to certain of its conditions of life, while others are important in other respects.

Directions: For each of the following statements about mammalian anatomy, blacken answer space

A if it is true and helps adapt the mammal to its particular condition of life.
B if it is true chiefly because of the evolutionary and embryological history of mammals.
C if it is true chiefly because the mammal is a large multicellular animal.
D if it is false.

363. (3.00) The structure of the respiratory organs insures that the humidity of air in the alveoli remains high throughout the course of inspiration and expiration.

364. (3.00) The air passage and the food passage intersect in the pharynx.

365. (3.00) All parts of the body are supplied with vessels to carry blood to and from the parts.

366. (3.00) Esophagus, vena cava, trachea, and aorta all pierce the diaphragm.

367. (3.00) The structure of both the male and the female reproductive tracts is suited to the occurrence of fertilization within the female reproductive tract.

368. (3.00) As a rule, the proportion of body weight attributable to limbs is higher than for modern reptiles, fish, or salamanders.

27. *Classification of Plants*

CLASSIFICATION OF PLANTS

1. (1.10) The principal use of red algae is

A. for beautiful decorations. **B.** for making dyes.
C. as a source of phycocolloids.
D. as food for livestock. **E.** in fertilizer manufacture.

2. (1.10) The microscopic organisms living near the surface of water, either fresh or salt, are known collectively as

A. microbes. **B.** kelps. **C.** plankton.
D. blue-green algae. **E.** protozoa.

3. (1.10) Taxonomy can be defined as

A. the study of plant and animal distribution.
B. the scientific classification of plants and animals.
C. the sum total of factors affecting evolution.
D. the geological time scale.
E. the study of vestigial organs.

Items 4 - 13 are based on the key list below.

KEY

A. Fern. **B.** Moss. **C.** Alga. **D.** Flowering plant.
E. Yeast.

4. (1.10) Sporophyte contains vascular tissue; swimming sperms occur.

5. (1.10) Mature multicellular sporophyte remains attached to gametophyte.

6. (1.10) Pollination occurs. **7.** (1.10) No photosynthesis occurs.

8. (1.10) Microspores and megaspores are produced.

9. (1.10) Zygote is usually only diploid cell of photosynthetic plant.

10. (1.10) True, stems, roots, and leaves occur, but no seeds are produced.

11. (1.10) Embryo may be surrounded by nutritive tissue and enclosed in protective coats.

12. (1.10) Active plant could survive for months in absence of light.

13. (1.10) Sori occur.

14. (1.10) Common bread mold (Rhizopus) is a (an)

A. Myxomycete. **B.** Phycomycete.
C. Ascomycete. **D.** Basidiomycete.
E. Deuteromycete.

15. (1.10) An angiosperm is a plant which

A. bears seed in an ovary. **B.** has naked seeds.
C. has no chlorophyll. **D.** produces no fruits.
E. produces no flowers.

16. (1.20) Of the following, the one which is *not* a fungus is

A. mushroom. **B.** smut. **C.** mold. **D.** yeast.
E. moss.

17. (1.20) Pine belongs to a group of plants characterized as

A. thalloid. **B.** enclosed seeded.
C. non-seed bearing. **D.** spore-forming.
E. naked seeded.

18. (1.20) From the standpoint of our conception of evolutionary complexity, which one of the following plants occupies the same position in relation to the other four as mankind occupies in relation to all the other species of animals, living and extinct?

A. Dandelion. **B.** Pine. **C.** Modern Fern.
D. Moss. **E.** Seed fern.

Items 19 - 36.

The following categories are in order of decreasing extent of application. After each item number on the answer sheet, blacken the *one* lettered space which designates the category to which the item applies.

A All living organisms.
B Most species of animals *and* most species of plants.
C Most species of animals *or* most species of plants.
D A group of plants *or* animals comparable to a single phylum or an important sub-phylum.
E A group of plants or animals smaller than any of the preceding groupings, more specifically, a single class of *either.*

19. (1.20) The possession of chlorophyll.

20. (1.20) The process or respiration.

21. (1.20) The possession of supporting tissue of some degree of differentiation.

22. (1.20) The possession of cellulose cell walls.

23. (1.20) The possession of a system of some degree of complexity for transporting materials within the bodies of organisms.

24. (1.20) The transformation of lifeless food into living protoplasm.

25. (1.20) Reproduction by means of seeds.

26. (1.20) The possession of a metabolism.

27. (1.20) The possession of a multicellular body.

28. (1.20) The elimination of wastes.

29. (1.20) The possession of a protective covering tissue.

30. (1.20) The possession of vertebrae.

31. (1.20) The possession of mammary glands.

32. (1.20) The quality of being sensitive to environmental influences.

33. (1.20) Some form of sexual reproduction.

34. (1.20) The occurrence of diffusion in some part of the organism.

35. (1.20) Some differentiation of nervous tissue.

36. (1.20) The embryonic young are nourished by means of a placenta.

37. (1.20) The oak tree is a

A. fungus. **B.** moss. **C.** fern. **D.** bryophyte
E. flowering plant.

38. (1.20) Fungi differ from green plants in that typically they

- **A.** are unicellular.
- **B.** lack the ability to manufacture their own food from inorganic substances.
- **C.** differ in cell structure and color.
- **D.** do not grow in the presence of light.
- **E.** do not possess cell walls.

39. (1.20) All animals with a true coelom have or display

- **A.** a cuticle. **B.** segmentation.
- **C.** a single, multi-chambered heart.
- **D.** a single median brain, or 2 brain lobes.
- **E.** separate musculature for the body.

40. (1.20) Pteridophytes rank higher than Bryophytes in the plant kingdom because they

- **A.** are the dominant land plants today.
- **B.** have multicellular sex organs.
- **C.** have true roots, stems and leaves.
- **D.** are larger plants. **E.** have non-flagellate sperms.

41 - 46. Kinds of bacteria.

A. chemosynthetic bacteria. **B.** denitrifying bacteria.
C. nitrifying bacteria. **D.** nitrogen fixing bacteria.
E. pathenogenic bacteria.

To which of the above do the following belong?

41. (1.20) Bacteria which change nitrites to nitrates.

42. (1.20) Bacteria which change nitrites to free nitrogen.

43. (1.20) Bacteria which change free nitrogen to substances which may be used by green plants.

44. (1.20) Bacteria which manufacture food from inorganic materials without light.

45. (1.20) Bacteria which change ammonia to nitrites.

46. (1.20) Bacteria which change nitrates to nitrites.

47. (1.20) The Redwood trees are

A. bryophytes. **B.** conifers. **C.** dicotyledons.
D. cycads. **E.** monocotyledons.

Item 48 deleted.

Items 49 - 55 are based on the key list of groups of organisms below.

KEY

A. Thallophyta. **B.** Bryophyta. **C.** Protista.
D. Pteridophyta. **E.** Spermatophyta.

49. (1.20) Which function solely on the protoplasmic level?

A. A. **B.** B. **C.** C. **D.** D. **E.** E.

50. (1.20) Which possess stomata but lack vascular tissue?

A. A. **B.** B. **C.** C. **D.** D. **E.** E.

51. (1.20) Which group includes both animals and plants?

A. A. **B.** B. **C.** C. **D.** D. **E.** E.

52. (1.20) Which two groups partially include the same organism?

A. A and B. **B.** A and C. **C.** B and C.
D. C and D. **E.** B and D.

53. (1.20) Which three contain species lacking chlorophyll?

A. A, B, and C. **B.** B, C, and D.
C. C, D, and E. **D.** A, C, and E.
E. A, C, and B.

54. (1.20) Rhizoids are found in the gametophyte generation of

A. A and B. **B.** B and C. **C.** C and D.
D. D and E. **E.** B and D.

55. (1.20) The groups from the key list in which asexual reproduction occurs are

A. A and C only. **B.** A and B only.
C. A, B, and C only. **D.** A, B, C, and D only.
E. A, B, C, D, and E.

56. (2.20) The chief reason Linnaeus gives for his preference for (a) the listing of points which differentiate one species from the others in its genus over (b) the complete description of the typical member of the species is

- **A.** the greater ease and certainty in identifying the species to which a plant belongs than of identifying the genus.
- **B.** the degree of variability in points, some minor and some major, between the members of a single species.
- **C.** the greater system and order achieved by the *latter* procedure.
- **D.** that the various species within a genus are united by common descent.
- **E.** that the genera are groups composed of organisms which have more shared than differentiating characteristics.

57. (4.20) In order to be able to judge whether a part of a plant is variable, in Linnaeus' sense, one must always

- **A.** be acquainted with all the species in a genus.
- **B.** be acquainted with all the species of plants.
- **C.** examine all the plants in the species.

D. grow seeds from one plant under several different environmental conditions.

E. have some criterion or criteria of what constitutes the species other than the form of that part.

58. (4.20) The major premise or assumption on which rests Linnaeus' argument (by analogy with man) that "the specific name should be taken from those parts of the plant which are not variable" is that

A. specific differences are to be found in important parts of the plant, not in trivial parts.

B. variable parts of the plant are less easy to judge in the absence of members of other species of the same genus.

C. the variability is due to what Darwin calls the "definite action of the conditions of life."

D. plants related by common descent belong to the same species, no new species having come into existence after the Creation.

E. the wider the botanical acquaintance of a taxonomist (classifier), the more species he describes.

P

28. *Health and Human Behavior*

HEALTH AND HUMAN BEHAVIOR

1. (1.10) Active acquired immunity is the result of the production of

A. proteins. B. vaccines. C. filterable viruses.
D. serums. E. antibodies.

2. (1.10) The protective adaptation that has guarded against the greatest single danger to the human body is the

A. enzyme action of insulin.
B. respiratory reflex leading to coughing or sneezing.
C. elimination of urea by the kidneys.
D. clotting of blood.
E. destruction of harmful bacteria by white corpuscles.

3. (1.10) The point at which medical science turned from primary emphasis on anatomy to emphasis on physiology was marked by

A. the publication of Parcelsus' *Volumen Paramirum.*
B. the appearance of Hippocrates' *On the Nature of Man.*
C. Robert Koch's isolation of the tubercle bacillus.
D. the appearance of Francis Bacon's *Novum Organum.*
E. the perfection of the microscope by Leeuwenhoek to the point where it was possible to observe the capillary system.

4. (1.10) The fast freezing of foods is an effective way to

A. destroy bacteria without decomposing the food.
B. destroy bacteria with minor change in the form and caloric value of foods.
C. destroy bacteria with minimum altering of the vitamin content of food.
D. reduce bacterial growth in foods that are harmed by sterilization.
E. totally stop bacterial action as long as temperatures below freezing are maintained.

5. (1.10) Of the following, the most frequent and basic cause of delinquency is

A. innate deficiencies. B. low intelligence.
C. conflicts and frustrations. D. divorced parents.
E. lack of playground facilities.

6. (1.10) Comparing the results of an intelligence test given to large numbers of unselected Negroes and whites, we find that

A. very few Negroes are less intelligent than the average white group.
B. both groups do equally well on the test.
C. the Negroes on the average get lower scores than the whites.
D. the Negroes vary more, getting more extremely low and high scores than the whites.

7. (1.10) In our culture a general characteristic of adolescent growth and development is

A. emerging heterosexual practices.
B. increasing amount of participation in games and sports.
C. low level of interest in the daily environment.
D. increased egocentric participation.

8. (1.10) The maximum effects of a cocktail before dinner are likely to come within

A. 5 minutes. B. 30 minutes. C. 2 hours
D. 3½ hours or more.

9. (1.10) The usual alcoholic content of whisky is

A. 1-2%. B. 3-6%. C. 7-12%. D. 13-25%.
E. 26-50%.

10. (1.10) A good way to make conversation is to

A. center the talk on a topic you know well.
B. talk about mutual friends who are not present.
C. let others do the talking.
D. talk about a subject in which others are interested.

11. (1.10) Most psychologists today are

A. behaviorists. B. introspectionists.
C. psychoanalysts. D. configurationists.
E. not any of these.

12. (1.10) ". . . the limitation of freedom of movement of persons or animals who have been exposed to communicable disease for a period of time equal to the longest usual incubation period of the disease to which they have been exposed." This definition refers to

A. isolation. B. separation. C. confinement.
D. quarantine. E. prevention.

13. (1.10) The life expectancy of humans in the United States is

A. different for males and females.
B. longer for females because the mortality rate is higher.
C. longer for individuals in Minnesota than in South Dakota.
D. the same today as it was in the year 1900.
E. the period from birth to the upper biological limits of age.

14. (1.10) Cancer in man can be best defined as

A. inflamed tissue. B. a malignant growth of cells.
C. excess tissue.
D. any cells which multiply rapidly. E. any tumor.

15. (1.10) Radiation (such as X-rays) is used in treatment of cancer because

A. cells which are rapidly dividing are more susceptible to radiation damage.
B. X-rays are able to penetrate practically anything.
C. X-rays can cause cancer and therefore can cure it.

16. (1.10) Manic-depressive psychosis constitutes

A. a case in which the individual has "retreated to childhood."
B. an exaggeration of the normal "ups and downs" of mood.
C. a generally "mixed up" condition.

17. (1.10) Organic mental disorders are those

A. which affect the organs of the body.
B. which do not have to be institutionalized.
C. which can be traced to a definite physical cause.

18. (1.10) Neuroses are

A. mild mental disorders whose victims can still get along in normal society.
B. severe mental disorders whose victims have to be institutionalized.
C. exaggerations of normal "ups and downs" of mood.

19. (1.10) Paranoid psychoses are those

A. in which the individual exhibits complete loss of memory.
B. in which the individual has delusions of grandeur and believes others are plotting against him.
C. in which the individual exhibits complete withdrawal and refuses to communicate.

20. (1.10) A common laboratory test used to help in diagnosing disease:

A. Copper Sulphate test. **B.** Vermin analysis.
C. Urine analysis. **D.** pH. **E.** H_2S.

21. (1.10) Lime and alum are added to water in the treatment plant to

A. destroy taste and odor. **B.** add oxygen.
C. destroy disease bacteria.
D. precipitate suspended matter. **E.** sweeten it.

22. (1.10) At the sewage treatment plant the filtration beds are dependent upon

A. aerobic **B.** anerobic **C.** antibiotic
D. pathogenic **E.** parasitic organisms for their action

True or False.

23. (1.10) Early sewers were for drainage purposes and not disposal of excreta and wastes.

True or False.

24. (1.10) Isolation was early recognized as a preventative measure.

True or False.

25. (1.10) County health units have been in existence longer than city or state health units.

True or False.

26. (1.10) Osteopaths are practicioners who effect treatments through manipulations of muscles and bones.

True or False.

27. (1.10) Alcoholism is a major disease.

True or False.

28. (1.10) It is a fact that one-third of the population of the United States is now on inadequate diet.

True or False.

29. (1.10) The interval between exposure to an infection and the appearance of the first symptoms is called the incubation period.

True or False.

30. (1.10) Use of alcohol as a therapeutic agent is recognized by the American Medical Association.

31. (1.10) According to Diehl, the best way for the average middle-aged business man to build up his energy reserve and to revitalize his zest for living is to

A. ski, bowl or play golf at least once a week.
B. enroll in a gymnastics course in which swimming, handball and gym exercise are followed by hot and cold showers and brisk massage.
C. go on a long motor trip to the mountains and spend most of the time hiking in the fresh air.
D. take a five-mile hike every morning before beginning the day's work.
E. tell his friends he has gone on a vacation, cut off the telephone, stay home and rest.

32. (1.10) Penicillin is produced by

A. yeast. **B.** bacteria. **C.** rusts. **D.** mold.
E. algae.

33. (1.10) An apparent stomach ache may really be an indication of

A. diabetes. **B.** appendicitis. **C.** tuberculosis.
D. diphtheria. **E.** scurvey.

34. (1.10) The drug, penicillin,

A. was first produced in pure form by the French scientist Louis Pasteur.
B. was discovered incidentally by the British scientist, Sir Alexander Fleming.
C. was developed bv the large German chemical firm, I. G. Farbenindustrie, just prior to World War II.
D. was developed from one of the sulfa drugs by the United States Public Health Service.
E. is produced as a by-product of aspirin by one of the American drug companies.

35. (1.10) The bacteria normally inhabiting the large intestine of man

A. constitute a serious menace to health.
B. are usually harmless as long as they do not invade other parts of the body.
C. are constantly poisoning the system necessitating frequent medical attention.
D. are more important in carnivores and in man than in the herbivorous animals.
E. cause nearly everybody to have appendicitis sooner or later.

36. (1.10) All except which one of the following result directly or indirectly from widespread famine?

A. Decreased resistance to infectious disease.
B. Closer family unity and dependence of members of the family upon each other.
C. Closer association of rodents with man.
D. Increased prostitution.
E. Increased mobility of the population.

37. (1.10) The Federal Food and Drug Act prohibits

A. false advertising of all kinds.
B. sale of the product if the chemical contents are not itemized on the package.
C. false radio advertising of certain products.
D. false advertising on the package.

38. (1.20) Which of the following best explains the fact that people act differently when in a crowd or mob than they do individually?

A. There develops a crowd mind which is substituted for the individual mind.
B. The suggestibility of an individual decreases in direct proportion to the size of the group of which he is a part.
C. The close proximity of large numbers of people acts as a depressant on the cerebral cortex.

D. Crowd behavior is by nature a more primitive type of behavior.
E. There is a loss of the feeling of individual responsibility.

39. (1.20) The solidarity of the youthful gang is, for the most part, the result of

A. conflict with other social groups and forces.
B. maturation, and is found mostly in gangs of older boys.
C. sex differences.
D. codes, passwords, and other devices of secrecy.

40. (1.20) One might observe the effect of *social facilitation* by which of the following methods?

A. Observing the changes in behavior of individuals as they become a part of a group.
B. Comparing the typing speed of a typist working alone with that of another typist working with others.
C. Comparing the difference in speed of the same typist working alone and working with other typists.
D. Noting differences in the galvanic skin response (GSR) of an individual when alone and when part of a group.
E. Depending on the situation, any of the above methods may be used.

41. (1.20) Suppose that a national program for the diagnosis, segregation (guarding), and sterilization of the feebleminded were instituted. The most probable result(s) would be to

A. eliminate feeblemindedness within about 5 generations.
B. reduce appreciably the number of major crimes.
C. reduce the birth rate slightly in the remainder of the population.
D. improve the intellectual level of the population slightly.
E. do all of the above.

42. (1.20) Difference in attitudes and points of view between old people and young people today are perhaps a major cause of some adolescent problems. These differences are best understood when related to

A. the greater amount of physical energy possessed by young people.
B. the inexperience of younger people.
C. difference in cultural background.
D. the less liberal attitudes of older people.
E. all of these factors.

43. (1.20) If you are using liquor at all, it is probably best to use it when

A. you drive into town for a good time with a girl (boy) friend.
B. an acquaintance introduces you to a congenial group of people at a dance.
C. you are having a dinner party with some friends (neighbors).
D. you have rather difficult work to be done and you need a "lift."
E. you are over-confident and need to be "toned-down."

44. (1.20) A primary drawback to the use of alcohol in a situation demanding important decisions is that it

A. speeds up the heart beat.
B. rapidly increases fatigue.
C. makes one less critical.
D. makes one more prone to waver from one decision to another.

45. (1.20) What is the probable effect of alcohol in moderate doses?

A. To increase emotional strength.
B. To decrease emotional and sexual strength but to tend to release whatever emotional and sex desires are present.
C. To make people capable of more frequent and intense sexual reactions.
D. To increase the strength of certain emotions like sadness or jollity more than others.

46. (1.20) Which of the following statements represents a basic difference between propaganda and education?

A. Education is aimed at enlightenment while propaganda is not.
B. Education presents both sides of a question while propaganda presents only one side.
C. Education appeals to the intellect; propaganda only to the emotions.
D. Education is designed to alter concepts; propaganda to alter behavior.
E. Education relies on facts; propaganda on prejudice.

47. (1.20) How do people commonly react to the announcement of a new medical discovery?

A. They pay little attention to it.
B. They are skeptical of the real value of the discovery.
C. They are cautious and refuse to try the new discovery until doctors have tested it thoroughly.
D. They believe the most optimistic claims and expect their doctors to make use of the discovery at once.

48. (1.20) Which of the following is the only consequence of eugenic sterilization of a human being?

A. Modification of secondary sexual characteristics.
B. Loss of interest in the opposite sex.
C. Cessation of egg or sperm production in the body.
D. Cessation of sex hormone production.
E. Loss of procreative capacity.

49. (1.20) Allergies are most closely associated with

A. the production of toxins by bacteria.
B. a modification of the antigen-antibody reaction.
C. transmission of characteristics by heredity.
D. disturbances between the interrelated endocrine glands.
E. abnormal mental associations between objects or materials and malfunctioning of the lymphatic system.

50. (1.20) Which of the following marks the beginning of man's unique learning process; that is, as it is distinguished from the learning of other animals?

A. Curiosity about actual objects in the environment.
B. Perception of objects by means of the senses.
C. Reaction to real objects in the environment.
D. Adjustment of operational behavior to "signs" in the immediate environment.
E. Inquisitiveness, expressed in symbols, about the real environment.

51. (1.20) Which one of the following is not included among the ten leading causes of mortality in the United States?

A. Poliomyelitis. B. Heart disease. C. Cancer.
D. Accidents. E. Pneumonia.

52. (1.20) Any factor which reduces the white blood cell count is also likely to

A. produce leukemia.
B. reduce the body's resistance to infection.
C. result in cancer. **D.** induce insomnia.
E. produce heart disease.

53. (1.20) Generally speaking, when the entire world population is considered, the human body's most effective defense against disease is probably the

A. white blood cells. **B.** antigen-antibody reactions.
C. immunity inherited by all infants.
D. immunity acquired by inoculation.
E. skin and linings of organs.

54. (1.20) The abnormal reaction of organisms in such maladies as hay fever, food allergies, and blood transfusion mismatches, is due primarily to the presence of

A. carbohydrates. **B.** fibrinogen. **C.** enzymes.
D. antigens. **E.** fatty acids.

55. (1.20) What is most likely to happen when an Rh-negative woman carries an Rh-positive fetus in her first pregnancy?

A. There is little likelihood that the child will have erythroblastosis.
B. The child will die unless it receives a complete blood transfusion at birth.
C. The child will most likely be anemic and feebleminded.
D. The child can live only if pregnancy is terminated at seven months by Caesarean operation.
E. The child will be certain to be afflicted with erythroblastosis fetalis.

56. (1.20) Which of the following provides evidence that most grown-ups have been carriers of some diseases that have gone unrecognized?

A. Adults have acquired immunity by mild exposure to many diseases to which children are highly susceptible.
B. Most people living in civilized countries have had at least one or more vaccinations during their lifetime.
C. Many people have escaped illness in childhood and youth by living under highly sheltered and strictly sanitary conditions.
D. Most diseases do not have clear-cut symptoms and leave no noticeable after-effects.

57. (1.20) Passive immunity differs from active immunity in that

A. the body produces its own antibodies in passive immunity.
B. it is more permanent than active immunity.
C. a longer time is required to develop passive immunity.
D. passive immunity is immediately produced by injection of antibodies from another organism.
E. in passive immunity a vaccine is used which contains either dead or weakened disease-producing bacteria or viruses.

58. (1.20) High blood pressure may be a symptom of all of the following conditions *except*

A. muscular exertion. **B.** shock.
C. emotional excitement. **D.** disease.
E. sudden changes in environmental temperatures.

59. (1.20) In preparation for which test must a person refrain from eating and from muscular exercise for several hours preceding the test?

A. Wassermann test. **B.** Basal metabolism test.
C. Test for tapeworm infestation.
D. Urinalysis for diabetes. **E.** Rh-factor test.

Questions 60 thru 64 tell a short story. For each statement mark

A if it is an *objective observation.*
B if it is a *subjective observation.*
C if it is an *interpretation* or *inference.*

60. (1.20) I went to one of the clothing stores and was directed to the suit department on the second floor.

61. (1.20) The salesman who spoke to me was over-enthusiastic.

62. (1.20) I found my attention wandering.

63. (1.20) He said he had just what I wanted downstairs, so he left and brought back another suit, which I did not buy.

64. (1.20) The salesman annoyed me.

65. (1.20) The salesman was quite discouraged.

66. (1.20) The major drawback to the use of anecdotal records is that

A. they are necessarily lengthy.
B. they will be meaningless except to the observer and recorder.
C. the bias of the observer is frequently reflected in the record.
D. the records are not quantitative and therefore cannot be analyzed statistically.

67. (1.20) From the standpoint of psychology as a science, what would most likely be a psychologist's position in a discussion of free will vs. determinism?

A. The acceptance of free will would mean that we could never develop a science which could predict and control behavior.
B. The acceptance of free will is tantamount to the acceptance of God, which no psychologist will or can accept.
C. The acceptance of determinism is tantamount to the acceptance of fatalism, which is not psychologically sound.
D. The acceptance of determinism would relieve us of any moral responsibility and eventually lead us to chaos.
E. Whether you accept one or the other is a matter of principle and relativity and not worth further discussion.

68. (1.20) If you wish to estimate the relative contribution of heredity and environment in determining the deviant behavior of a delinquent boy, which of the following methods would you use?

A. Experiment. **B.** Dream analysis. **C.** Schick test.
D. Personality testing. **E.** Case history.

69. (1.20) Most important of the following items in establishing that a specific organism is the cause of a specific disease is that it must be

A. grown on artificial media.
B. able to infect other animals.
C. associated with all victims.
D. found in a healthy individual.
E. found in a victim.

70. (1.20) Claims have been made that vaccination does not prevent smallpox, but weakens the person's resistance, so that he is more susceptible to the disease. From our knowledge of vaccination today, we can conclude that

A. vaccination does not do any harm, but its value is questionable.
B. vaccination is one of the most positive preventives of disease known.
C. vaccination weakens resistance and makes one more susceptible to disease.
D. it has never been proved that vaccination prevents disease.
E. vaccination worked well for some persons but not for others.

71. (1.20) Infants under one year of age should be immunized to small pox, diphtheria and whooping cough because these diseases

A. affect only infants. **B.** claim a high death rate.
C. represent major health problems today.
D. might strike one anytime in life.
E. are considered infectious.

72. (1.20) A child is already ill with diphtheria. He will benefit most from

A. the Schick test. **B.** exercise and sunlight.
C. injection of antitoxin.
D. injection of toxoid or toxin-antitoxin.
E. complete bed rest and a nutritious diet.

73. (1.20) The best way to avoid having colds is to

A. expose the body regularly to ultra-violet light during winter.
B. take cold showers to build up resistance.
C. take daily doses of multiple vitamins.
D. increase general resistance by hygienic living.
E. take cold vaccine orally.

Items 74 - 83.

Directions: Here are five subject-matter fields which deal with the study of human values and behavior. Indicate which of the five deals directly with each of the specific problems presented in items 74 through 83 by blacking out the number of that subject matter-field on the answer sheet. *There is only one correct answer to each question.*

A. Anthropology. **B.** Mental Hygiene.
C. Sociology. **D.** Philosophy. **E.** Psychology.

74. (1.20) What are some typical symptoms of emotional maladjustment?

75. (1.20) Which life values may be regarded as good and which as evil?

76. (1.20) What are the major differences between American and Chinese cultural patterns?

77. (1.20) What abilities and interests are required for successful job performance in the field of accounting?

78. (1.20) How does the family influence the development of ethical standards and social customs?

79. (1.20) What are the principal pitfalls and fallacies to be avoided in reasoning?

80. (1.20) What differences in mental ability exist between adolescents and people over sixty?

81. (1.20) What are some techniques by which ordinary persons can learn to recognize and deal with their own anxieties and tensions?

82. (1.20) Does man possess a free will?

83. (1.20) What are the most effective methods of studying for an examination?

84. (1.20) The view which the science of psychology takes toward human behavior is that it is

A. subject to different laws from those governing the behavior of lower animals.
B. incapable of experimental investigation by the subjective method.
C. endowed with certain limited supernatural powers.
D. understandable in terms of the fundamental principle of the conditioned response.
E. capable of explanation in terms of natural law.

85. (1.20) A chief advantage of the principle of objectivity in the scientific study of human behavior is that it

A. yields results which are completely accurate.
B. encourages maximum use of the experimenter's insight and personal experience.
C. permits the development of perfectly valid psychological tests.
D. produces results divorced from the experimenter's biases and opinions.
E. eliminates the necessity of obtaining the experimental subject's personal feelings and subjective reactions.

86. (1.20) The fact that the I.Q.'s of children can be somewhat modified through training would most strongly suggest that

A. intelligence is not really "the capacity to learn."
B. feeblemindedness may not have a hereditary basis.
C. I.Q.'s fluctuate too much to be useful for purposes of predicting future mental behavior.
D. intelligence tests do not directly measure inborn mental ability.
E. more geniuses are produced through excellent environment than through excellent heredity.

87. (1.20) Good health is best thought of as the condition in which the body is

A. free of all harmful bacteria.
B. in a state of well-being **C.** free of all discomfort.
D. ready to act fully, restore, and renew itself.
E. not afflicted by major diseases.

88. (1.20) An individual may be considered completely dead when

A. the heart stops beating.
B. all the cells of the body stop functioning.
C. the individual stops breathing.
D. the blood stops circulating through the body.
E. "rigor mortis" sets in.

89. (1.20) The short-term effect of caffeine on man is to

A. generally produce insomnia.
B. stimulate physiological processes.
C. increase the capacity to do physical work.
D. increase his mental capacity. E. aid his digestion.

90. (1.20) The habitual use of tobacco by man

A. aids digestion in high-strung individuals.
B. is not known definitely to impair health.
C. calms the nerves by acting as a sedative.
D. stimulates mental and physical activity.
E. makes heart action sluggish and irregular.

91. (1.20) Alcohol consumed by man exerts an anesesthetic effect through the

A. dehydration of tissues. B. killing of cells.
C. oxidation of the alcohol.
D. paralysis of nerve centers.
E. dilation of blood vessels.

92. (1.20) One of the following symptoms would *not* be considered a danger signal of cancer in man

A. any sore that does not heal.
B. irregular bowel movements.
C. persistent lump or thickening.
D. persistent indigestion. E. any irregular bleeding.

93. (1.20) The only safe and certain way to lose weight is to

A. eat a normal well-balanced diet and limit the caloric intake.
B. eat a normal well-balanced diet and increase the basal metabolism.
C. eat a normal well-balanced diet and exercise a lot.
D. substantially reduce the amount of food eaten until the desired weight is lost.
E. not eat any food but take special vitamin and mineral concentrate.

94. (1.20) If one wishes to sleep better at night, it is best to

A. avoid daytime naps.
B. be certain to get in the required number of hours.
C. not break his daily cycle.
D. avoid eating food or drinking coffee before retiring.
E. resort to sedatives.

95. (1.20) Exposure of the human body to sunlight

A. will, over a period of time, destroy bacteria within the body.
B. may, if excessive, cause a skin cancer to develop.
C. will result in nervous tension.
D. will increase resistance to colds.
E. may build an immunity to infectious diseases.

96. (1.20) Dental caries or decayed teeth

A. are definitely known to be caused by sugar.
B. are always caused by improper cleaning of teeth.
C. can be entirely prevented from knowledge available to dentists today.
D. can occur in well-cared-for teeth.
E. usually result from improper chewing of foods.

97. (1.20) Drugs which produce mental hallucinations are classed as

A. stimulants. B. hypnotics. C. antibiotics.
D. pathogenic. E. opiates.

98. (1.20) Alcoholic intoxication has all except which one of the following effects upon the nervous system?

A. Stimulation. B. De-sensitivity to pain.
C. Decreased visual acuteness. D. Depression.
E. Increased reaction time.

99. (1.20) Which of the following types of inoculation would result in passive immunity?

A. Immunization for typhoid fever.
B. Vaccination for small pox.
C. Immunization against influenza.
D. Immunization against yellow fever.
E. Injection of anti-toxin for diphtheria.

100. (1.20) Which of the following would best characterize a deficiency disease?

A. Impaired nutrition from tapeworm infestation.
B. Depletion of energy and general weakness resulting from influenza.
C. Impaired physical and mental functioning due to hookworm infestation.
D. Bleeding gums, loosened teeth, swollen joints and brittle bones resulting from a lack of ascorbic acid in the diet.
E. Loss of vitality which lingers long after contraction of malaria.

101. (1.20) Rickets would most likely be caused by which of the following?

A. Frequent prolonged exposure to cold and dampness.
B. Insufficient vitamin D in the diet.
C. An inadequate amount of sleep.
D. Inheritance of a predisposing tendency to the disease.
E. A filtrable virus borne in impure milk and water.

103. (1.20) In the progressive effect of syphilis on the body which of the following stages is out of proper sequence?

A. infection. B. formation of chancre or sore.
C. latent period. D. inflamed eyelids.
E. partial paralysis of nervous system.

104. (1.20) Four of the following are considered by many authorities to be examples of unlearned automatic behavior. Which one is *not*?

A. A pair of Baltimore Orioles building a nest just like the nests in which they were reared.
B. A young kitten suckling milk from its mother.
C. An adult person breathing through eight hours of continuous sleep.
D. A child who becomes frightened and cries at the sight of a snake.
E. A batch of newly hatched chicks, just removed from the incubator, pecking grains of sand and mash.

One of the expected outcomes of general biological science training is the ability to evaluate a medical diagnosis.

Items 105 - 112 are concerned with certain body disorders or conditions of malfunctioning which can be diagnosed by certain techniques in a medical examination. For each item select from the key the technique which would be used by a competent physician to detect the disorder or malfunction named in the item.

A. Urine sample. B. Blood sample.
C. Electrocardiograph. D. Chest fluoroscopy.
E. Basal metabolism test.

105. (1.20) Syphilis. **106.** (1.20) Diabetes. **107.** (1.20) Anemia.

108. (1.20) Goiter. **109.** (1.20) Kidney disease.

110. (1.20) Heart disease—irregularities in the heart beat.

111. (1.20) Appendicitis. **112.** (1.20) Drunkenness (legal definition of).

113. (1.20) Active immunity is acquired by

A. vaccination for smallpox.
B. the unborn infant from the mother against diphtheria.
C. injection of anti-toxin for diphtheria.
D. immunization for rabies by the Pasteur treatment.
E. taking quinine for malaria.

114. (1.20) A certain adult individual is extremely bow-legged and pigeon-chested. Which of the following may have been a possible cause of this condition?

A. Deficiency of vitamin D in the diet.
B. Premature birth. **C.** Extreme alcoholism.
D. Lack of vitamin A in the diet.
E. Overactive thyroid gland.

115. (1.20) An epidemic of diphtheria appears in your community. This indicates that

A. an epidemic of influenza will probably follow.
B. the diets of many people lack necessary vitamins.
C. many children have not been made immune to the disease.
D. the air is full of pollen.
E. sulphur should be burned daily in all homes.

116. (1.20) Which of the following is the most significant cause of the increase in demand for hospital services that has occurred in recent years?

A. The increased number of accidents.
B. The annual outbreak of polio.
C. The drive to discover all cases of active tuberculosis.
D. The development of hospitalization insurance plans.

117. (1.20) We suspect that our water supply may be polluted. One way to make the water safe to drink is to

A. filter it thru a mixture of charcoal and sand.
B. add approximately two milligrams of salt to each gallon of water.
C. boil it for at least twenty minutes.
D. filter it thru two or three thicknesses of filter paper.
E. add a half teaspoonful of soda to each gallon.

118. (1.20) Man lives healthfully in large cities because

A. there is an ample supply of well-trained physicians.
B. the hospitals give such excellent service.
C. the milk is pasteurized.
D. the greater number of brick buildings and cement basements prevent rat infestations.
E. pure water is supplied and sewage is properly disposed of.

119. (1.20) Intelligent behavior differs most from instinctive behavior in

A. social usefulness to the organism.
B. the extent to which maturation is a factor.
C. the possibility of variation of response to meet changed conditions.
D. being less dependent on learning and experience.
E. the fact that little trial and error is involved in intelligent behavior.

120. (1.20) Thinking in man is presumed to differ most from thinking in other animals in that

A. ideas are handled in terms of language symbols.
B. trial and error learning is not involved.
C. motivation is not an important factor.
D. man alone is able to deal with novel problems.
E. man is able to rationalize his behavior.

121. (2.20) A famous general was seated next to a Chinese diplomat at a banquet. After talking with others for some time, the general finally turned to the Chinese and asked "Likee soupee?" The Chinese smiled but said nothing. A little later he was called on by the chairman and made a fine speech in perfect English. Upon returning to his seat, he turned to the general and with a friendly smile, asked, "Likee speechee?" The general's question reflected

A. a stereotype. **B.** an hallucination.
C. an illusion. **D.** a social inhibition.

Item 122. Parent-child correlation in attitudes toward the church and communism.

	N	Church	Communism
Group selected to correlate highly in attitude toward church.	220	.96	.62
Group selected to correlate highly in attitude toward communism.	227	.74	.93
All cases, unselected.	1090	.63	.56

122. (2.20) On the basis of this table, which of the following is the best conclusion?

A. Children who resemble their parents in one attitude will not be likely to resemble them in the other.
B. Children who resemble their parents in one attitude will be likely to resemble them in the other.
C. There is only a slight tendency for children resembling their parents in one attitude to resemble them more closely in the other than do unselected cases.
D. A valid conclusion cannot be drawn because of the relatively small numbers in the selected groups as compared with the unselected group.

Items 123 - 128.

According to G. W. Allport, there are four ways in which attitudes are developed; they may be labeled (1) integration, (2) differentiation, (3) shock, and (4) adoption. Integration is the development of an attitude through accumulation of a large number of experiences over a long period of time, all of which influence the individual in a given direction. Thus, long-continued failure in solving arithmetic problems will be integrated by the pupil into an unfavorable attitude toward arithmetic. Development of an attitude by differentiation may be described as the splitting off of a specific attitude from a more general one, as when an individual has an unfavorable attitude toward arithmetic as a result of his unfavorable attitude toward all school subjects. Attitude development by shock is due to an unusual, violent, or painful experience; a child's attitude toward dentists may thus be quickly and forcefully molded by the experience of having a tooth pulled. Finally an attitude may be developed by adoption, in that the individual follows the example of friends, teachers, parents, newspapers, and other opinion-molding agencies; the daughter who is a Democrat mainly because her dad is one illustrates this way of developing an attitude.

Questions 123 thru 128 below describe situations in which attitudes have been developed. Classify each situation according to the above discussion by marking

A if the attitude was formed by *integration.*
B if formed by *differentiation.*
C if formed by *shock.*
D if formed by *adoption.*

123. (2.20) He has been afraid of swimming ever since he was "ducked" by an older boy at the age of three.

124. (2.20) He favors reciprocal trade agreements because of a belief in the merits of free enterprise.

125. (2.20) She can't dance very well. When asked to go with friends to learn to dance, she says she doesn't care to go.

126. (2.20) He has begun to dislike John because of John's habit of bumming cigarettes.

127. (2.20) He is campaigning for civil rights because everyone at Antioch seems to be doing that.

128. (2.20) Two weeks after arriving at Antioch a freshman is heard to say, "The Achievement Exams are certainly tough."

Questions 129 thru 132 are based on the table below

I	II	III	IV	V	VI
Trait	$\overline{D}_1$	$\overline{D}_2$	$\overline{D}_1$-$\overline{D}_2$	PE_D	*Diff.* PE_D
Height (cm)	1.80	1.61	0.19	0.31	0.6
Weight (lb)	9.90	4.03	5.87	1.22	4.8
Head length (mm)	2.20	2.59	–0.39	0.42	0.9
Head width (mm)	2.85	2.25	0.60	0.40	1.5
Binet IQ	8.21	5.35	2.86	0.95	3.0
Otis IQ	8.00	4.54	3.67	0.89	4.1
Stanford Ach'v't (months)	16.26	6.38	9.68	1.91	5.2
Woodworth-Mathews Personal Data	5.00	5.48	0.48	0.93	0.5

KEY

I. Traits.
II. $\overline{D}_1$ is means difference between identical twins reared apart.
III. $\overline{D}_2$ is means difference between identical twins reared together.
IV. $\overline{D}_1$-$\overline{D}_2$ is the difference between the means of twins reared apart and twins reared together.
V. is Probable Error of the difference.
VI. is difference between means (IV) divided by Probable Error of difference (V).

129. (2.20) Which measures (traits) clearly show the influence of environmental differences?

A. Height, weight, head length, head width.
B. Binet IQ, Otis IQ, Stanford Achievement Test, Woodworth-Mathews Personal Data.
C. Height, head length, head width, Woodworth-Mathews Personal Data.
D. Weight, Binet IQ, Otis IQ, Stanford Achievement Test.
E. all the traits listed in Column I.

130. (2.20) Which of the following conclusions from this data is justifiable?

A. Physical traits are primarily influenced by heredity.
B. Academic achievement is the most significantly variable of the traits measured.
C. Since both are negative in Column IV, head length and Woodworth-Mathews Personal Data are positively correlated.
D. The influence of environment varies with the trait measured.
E. Errors of measurement are so large as to make most of the data suspect.

131. (2.20) As evidence by this table, what factor(s) have been controlled?

A. All traits not listed in Column I.
B. All traits listed in Column I.
C. Heredity.
D. Heredity and postnatal environment.
E. Prenatal and postnatal environment.

132. (2.20) The Woodworth-Mathews Personal Data is a personality inventory. Which of the following hypotheses best explains the difference found for the two groups of twins on this test?

A. Personality like height is more strongly influenced by hereditary than by environmental factors.
B. The differences between the twin groups, tho' small, is negative (Col. IV). This means that twins reared together are more variable in personality. Therefore personality is more strongly influenced by environment.
C. Personality tests are often insufficiently reliable for use in individual comparisons. The unreliability of the test may obscure the effect of either heredity or environment.
D. Conflicting influences of heredity and environment have cancelled each other.

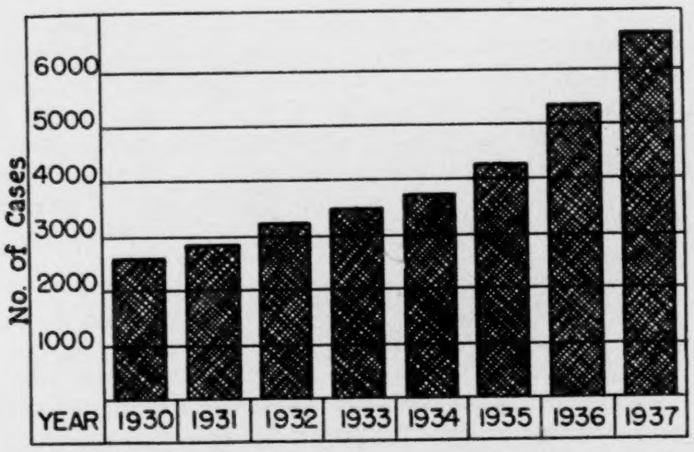
Items 133 - 142.

These data alone:

KEY

A. are sufficient to make the statement true.
B. are sufficient to indicate that the statement is probably true.
C. are not sufficient to indicate whether there is any degree of truth or falsity in the statement.
D. are sufficient to indicate that the statement is probably false.
E. are sufficient to indicate that the statement is false.

Problem I: **Below is a graph giving some information on new cases of syphilis reported in Kentucky each year from 1930 through 1937.**



133. (2.20) Every year from 1930 through 1937 there was an increase in the number of new cases of syphilis reported in Kentucky.

134. (2.20) There was no increase during the seven years in the number of new cases of syphilis reported for West Virginia.

135. (2.20) On learning of results like those shown in this study, people should become more concerned in the control of syphilis.

136. (2.20) The increase in the number of cases reported is due to better methods of diagnosis now used.

137. (2.20) The year showing the largest increase in the graph is 1936.

138. (2.20) There would be more than 5600 cases reported in 1938.

139. (2.20) At mid-year 1930-31 there were approximately 1000 cases.

140. (2.20) Since more syphilis cases were reported during the seven years from 1930 through 1937, more cases of syphilis must have occurred.

141. (2.20) This proves that clinics do no good.

142. (2.20) More cases were reported in 1937 than in the combined years 1935-36.

Item 143. Consider the following:

1. Harvey discovered the circulation of the blood when he was 72 years old.
2. Michelangelo and Titian painted masterpieces of art past 80.
3. Giuseppi Verdi composed the opera *Falstaff* at the age of 80.
4. Arturo Toscanini regularly conducted a major symphony orchestra at the age of 85.
5. Oliver Wendell Holmes was serving as a U. S. Supreme Court justice when 88.
6. Stradivarius made one of his world-famous violins at the age of 93.

143. (2.20) From the above and your readings in biological science the most valid conclusion would be

- A. Don't take life responsibilities too seriously in youth —there is time enough in old age for brilliant achievements.
- B. The mind functions better in old age than in youth or middle age.
- C. Potential mental output continues to increase right up to the end of life.
- D. Positions of statesmanship involving world responsibility had best be entrusted to those who are very old.
- E. Increased average longevity has been a major contributing factor in the rapid advance and enrichment of civilization.

Items 144 - 167 are based upon the data in the following table, plus your study of parasitism and disease.

Changes in the Leading Causes of Death in the United States Since 1900[*]

Disease—1900	Death rate per 100,000 Population All Ages	Disease—1940	Death rate per 100,000 Population All Ages
Tuberculosis	201.9	Heart Disease	292.5
Pneumonia	180.5	Cancer	120.3
Diarrhea and enteritis	133.2	Apoplexy	90.9
Heart disease	132.1	Nephritis	81.5
Diseases of early infancy and congenital malformations	91.8	Accidents	73.6
Nephritis	89.0	Pneumonia	54.9
Apoplexy	71.5	Diseases of early infancy and congenital malformations	49.2
Accidents	65.4	Tuberculosis	45.9
Cancer	65.0	Diabetes	26.6
Bronchitis	45.7	Arteriosclerosis	17.0
Typhoid fever	35.9	Influenza	15.3
Diphtheria	43.3	Suicide	14.4
Influenza	22.9	Syphilis	14.4
Peritonitis	15.1	Diarrhea and enteritis	10.3
Gastritis	14.0	Appendicitis	9.9
Diseases of pregnancy	13.3	Hernia, intestinal obstruction	9.0
Cirrhosis of the liver	12.9	Cirrhosis of the liver	8.6
Measles	12.5	Ulcer of stomach and duodenum	6.8
Hernia, intestinal obstructions	12.2	Diseases of pregnancy	6.7
Whooping cough	12.1	Diseases of the prostate	6.7

For each item, 144 - 167, mark space

- **A** if the data in the above table alone are sufficient to make the statement true or probably true.
- **B** if the data in the above table alone are sufficient to make the statement false or probably false.
- **C** if the data in the table and/or *other scientific knowledge* make the statement true or probably true.
- **D** if the data in the table and/or *other scientific knowledge* make the statement false or probably false.
- **E** if neither the data in the table nor present scientific knowledge justify a decision on the truth or falsity of this statement.

144. (2.20) The top ranking three diseases on the 1940 list are communicable infectious diseases.

145. (2.20) Advances in microbiology (bacteriology and parasitology) have been chiefly responsible for removal of the top ranking three diseases on the 1900 list to lower positions on the 1940 list.

146. (2.20) The number of deaths due to strangulation of part of the intestine in the male scrotum appears to be increasing.

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[*] Harold S. Diehl, *Textbook of Healthful Living*. By permission, McGraw-Hill Book Co., Inc., New York: 1955.

147. (2.20) Increased incidence of diabetes is correlated with increased longevity.

148. (2.20) The reduction in incidence of typhoid fever has been due in large measure to more widespread use of waterborn sewage disposal and chemical treatment of sewage.

149. (2.20) The cure for most types of cancer will likely be achieved in the next ten years.

150. (2.20) The average death rate per 100,000 population for the 20 leading causes of death was about 25% higher in 1900 than in 1940.

151. (2.20) More deaths from hardening of the arteries were recorded per 100,000 population in 1940 than in 1900.

152. (2.20) The number of deaths from accidents tends to decrease as civilization advances.

153. (2.20) Venereal disease appears to be on the increase.

154. (2.20) Maternal and infant health and welfare are improving in the United States as a whole.

155. (2.20) Diarrhea and enteritis is less than 10% as prevalent as it was 40 years ago.

156. (2.20) Incidence of tuberculosis has decreased over 75% in the 40 year period.

157. (2.20) Man's average span of life will probably reach 100 years by the end of the present century.

158. (2.20) Increased average longevity in the United States is in part responsible for the elevation of heart disease, cancer, and apoplexy to the first three ranking positions on the 1940 list.

159. (2.20) The whooping cough death rate has been reduced in part by rather widespread use of inoculation.

160. (2.20) Predisposition to heart disease is hereditary.

161. (2.20) It is much more difficult to reduce the death rate from communicable diseases than to reduce the death rate from organic diseases.

162. (2.20) There is a positive correlation between the death rate from ulcer of the stomach and high strung nervous, overwrought living.

163. (2.20) Appendicitis is primarily an affliction of youth rather than of older people.

164. (2.20) The death rate from brain hemorrhage and blood clot in the brain (stroke) showed a considerable decrease from 1900 to 1940.

165. (2.20) The death rate from kidney disorder shows some decrease in 40 years.

166. (2.20) The death rate from influenza is on the increase.

167. (2.20) Reduced death rate from diphtheria is largely due to extensive immunization measures throughout the United States.

Items 168 to 171 refer to the following passage from McGuffey's *Fifth Eclectic Reader.*

1) That there should be more species of intelligent creatures above us, than there are of sensible and material below us, is probable to me from hence; that in all the visible corporeal world, we see no chasms, or no gaps. 2) All, quite down from us, the descent is by easy steps, and a continued series of things, that in each remove, differ very little, one from the other. 3) There are fishes that have wings, and are not strangers to the airy region; and there are some birds that are inhabitants of the water, whose blood is as cold as that of fishes, and their flesh so like in taste, that the scrupulous are allowed them on fish days.

4) There are animals so near of kin both to birds and beasts, that they are in the middle between both; amphibious animals link the terrestrial and aquatic together; seals live on land and at sea, and porpoises have the warm blood and entrails of a hog. 5) There are some brutes that seem to have as much knowledge and reason as some that are called men; and the animal and vegetable kingdoms are so nearly joined, that if you will take the lowest of one, and the highest of the other, there will scarce be perceived any great difference between them, and so on, till we come to the lowest and the most inorganical parts of matter, we shall find, everywhere, that the several species are linked together, and differ but in almost insensible degrees.

6) And when we consider the infinite power and wisdom of the maker, we have reason to think that it is suitable to the magnificent harmony of the universe, and the great design and infinite goodness of the architect, that the species of creatures should also, by gentle degrees, ascend upward from us, toward his infinite perfection, as we see they gradually descend from us downward; and, if this be probable, we have reason then, to be persuaded, that there are far more species of creatures above us, than there are beneath; we being in degrees of perfection much more remote from the infinite being of God, than we are from the lowest state of being, and that which approaches nearest to nothing. 7) And yet of all those distinct species, we have no clear, distinct idea.

168. (2.20) The hypothesis formulated by the author in this excerpt from McGuffey's *Fifth Eclectic Reader* can best be stated as

- **A.** there are animals more intelligent than man.
- **B.** there is a gradual ascent by easy steps in the complexity of animal forms from the simplest to man.
- **C.** there is a gradual ascent by easy steps in the complexity of all forms of life from the lowest plant or animal to man.
- **D.** just as there is a series of living things descending in complexity from man, so is there an ascending series from man to God.
- **E.** man is not as far advanced above simple forms as he would have us believe.

169. (2.20) Of the first five sentences of the above quotation, the one containing an unquestionably inaccurate statement is number________.

170. (2.20) The main subject discussed in the passage from McGuffey's *Fifth Eclectic Reader* is

- **A.** evolution.
- **B.** the characteristics of plants and animals.
- **C.** adaptations in plants and animals.
- **D.** the origin and purpose of life.
- **E.** teleology.

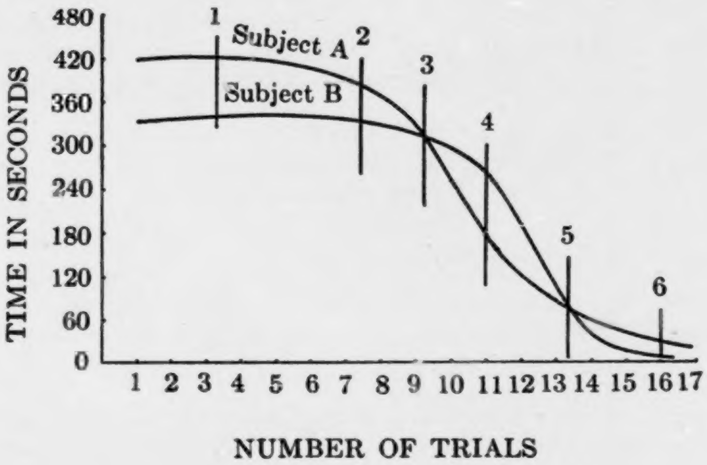
171. (2.20) Of the last five sentences of this quotation the one providing the most evidence that the author was familiar with the scientific method is

A. 3. **B.** 4. **C.** 5. **D.** 6. **E.** 7.

172. (2.20) The philosopher, Confucius, said, "Men's natures are alike, it is their habits that carry them apart." Interpreted in the light of modern concepts of race, this statement means

- **A.** that genetically human beings differ to a greater extent than they do culturally.
- **B.** that culturally people differ more than they do genetically.
- **C.** that genetically human beings are more alike than they appear to be on the surface.
- **D.** two of the above. **E.** none of the above.

Items 173 - 177 involve interpretation of the following graph which shows the rate at which two people learned to assemble a puzzle.



173. (2.20) For subject A, learning proceeded at the greatest rate in the neighborhood of the

A. first trial. **B.** third trial. **C.** sixth trial.
D. tenth trial. **E.** seventeenth trial.

174. (2.20) At which position is Subject A most definitely learning more rapidly than Subject B? (Positions 1, 2, 3, 4 and 5 are designated above the lines.)

175. (2.20) At which of the designated positions have both subjects attained most nearly the same degree of learning?

176. (2.20) Which of the following is the most valid conclusion to be drawn from the above data?

- **A.** Subject A has a higher I.Q. than Subject B.
- **B.** Subject B has a higher I.Q. than Subject A.
- **C.** Subject B has had more previous experience with puzzles than Subject A.
- **D.** Neither subject can be expected to show marked improvement with more practice.
- **E.** Subject A is more mechanically minded than Subject B.

Items 177 - 179 deleted.

180. (3.00) There were about 50 cases and four deaths from typhoid fever in Michigan in 1948 in comparison with 424 cases and 75 deaths in 1931. This marked decrease is attributable *primarily* to

- **A.** a rise in natural immunity.
- **B.** use of DDT in elimination of insects.
- **C.** a state-wide inoculation program.
- **D.** treatment of public water supply.
- **E.** food inspection and enforcement of regulations.

Items 181 - 198.

The quotations preceding each group of exercises are from a bulletin on the health of Soviet Premier Stalin, published in American newspapers just before his death.

After each exercise number on the answer sheet, blacken the *one* lettered space which designates the correct answer.

"J. V. Stalin had a sudden hemorrhage which affected vitally important parts of the brain as a result of which paralysis of the right leg and arm occurred, together with loss of consciousness and speech."

181. (3.00) The part of the brain involved in "paralysis of the right leg and arm" is the

A. back. **B.** front. **C.** left side.
D. right side. **E.** deep part.

182 (3.00) Stalin's "sudden hemorrhage of the brain" resulting in "paralysis of the right leg and arm" most probably directly affected the

A. cerebellum. **B.** cerebrum. **C.** medulla.
D. midbrain. **E.** thalamus.

183. (3.00) The specific area of the brain involved in the "paralysis of the right leg and arm" is most likely

- **A.** the association areas of the cerebrum.
- **B.** the muscular coordination areas of the cerebellum.
- **C.** the vomiting and swallowing center in the medulla.
- **D.** more than one of the above.
- **E.** none of the above.

184. (3.00) "Paralysis of the right leg and arm" probably occurred because the

- **A.** muscles were unable to contract under any condition.
- **B.** nerve fibers to the muscles were unable to transmit impulses.
- **C.** nerve fibers from the medulla to the spinal cord were unable to transmit impulses.
- **D.** impulses did not originate from higher centers in the brain.
- **E.** synaptic resistance of nerve fibers on the right side of the body were very high.

185. (3.00) Stalin's "loss of consciousness" most directly involved the

A. cerebellum. **B.** medulla. **C.** midbrain.
D. thalamus. **E.** cerebrum.

186. (3.00) His loss of "speech" most directly involved

A. the cerebellum. **B.** the cerebrum.
C. the medulla. **D.** the thalamus.
E. none of the above.

"Considerable disorders in breathing are being observed. The rate of breathing is up to 36 per minute . . ."

187. (3.00) Stalin's "disorder in breathing" probably most directly involved a center in

A. the cerebellum. **B.** the cerebrum.
C. the medulla. **D.** the midbrain.
E. none of the above.

188. (3.00) The chemical which controls the normal rhythm of breathing in a person at rest is

- **A.** the hormone from the parathyroids.
- **B.** thyroxin. **C.** carbon dioxide.
- **D.** muscle phosphate.
- **E.** a hormone from the pituitary.

189. Stalin's rate of breathing was approximately
(3.00)

A. twice the average rate of a healthy person at rest.
B. four times the average rate of a healthy person at rest.
C. six times the average rate of a healthy person at rest.
D. eight times the average rate of a healthy person at rest.
E. ten times the average rate of a healthy person at rest.

"His pulse rate is up to 120 per minute and completely irregular."

190. The average pulse rate of a healthy adult person at rest is
(3.00)
A. 35 per minute. **B.** 70 per minute.
C. 120 per minute.
D. the same as that of a person hard at work.
E. never the same.

191. Normally the pulse rate corresponds to the rate of
(3.00)

A. the heart beat. **B.** the flow of blood in veins.
C. the pressure of the blood in arteries.
D. the difference between systolic and diastolic blood pressure.
E. none of the above.

192. The pulse rate of "120 per minute" was most likely due to a disturbance of a center in
(3.00)

A. the cerebellum. **B.** the medulla.
C. the midbrain. **D.** the thalamus.
E. none of the above.

"The blood pressure maximum is 220, the minimum is 120."

193. The average blood pressure of a healthy 25 year old individual at rest is:
(3.00)

A. 40 "maximum" 20 "minimum."
B. 80 "maximum" 40 "minimum."
C. 130 "maximum" 90 "minimum."
D. 160 "maximum" 120 "minimum."
E. 220 "maximum" 120 "minimum."

194. The part of the brain which has centers that most directly influence the blood pressure by affecting the heart beat and vasomotor activities is the
(3.00)

A. cerebellum. **B.** cerebrum. **C.** medulla.
D. midbrain. **E.** thalamus.

195. The "maximum" blood pressure refers to the pressure of the blood in the arteries
(3.00)

A. at the height of ventricular contraction.
B. at the height of ventricular relaxation.
C. between auricular and ventricular contraction.
D. at the height of auricular contraction.
E. none of the above.

196. "Maximum" blood pressure is
(3.00)

A. greatest in the capillaries.
B. the same in all the blood vessels.
C. greatest in the large veins carrying blood into the heart.
D. greatest in the aorta.
E. greatest in the arteries carrying blood to the limbs.

"His temperature is 38.2 degrees centigrade (100.8 fahrenheit)."

197. The temperature of 100.8 degrees fahrenheit was approximately,
(3.00)

A. 0.8 degrees F. higher than normal.
B. 2 degrees F. higher than normal.
C. 28 degrees F. higher than normal.
D. 20 degrees F. lower than normal.
E. the same as normal.

198. The center which regulates temperature is in the
(3.00)

A. cerebellum. **B.** cerebrum. **C.** medulla.
D. midbrain. **E.** thalamus.

199. A diabetic patient took too much insulin which resulted in insulin shock because of an excessive drop in blood sugar level. Which of the following methods would give the most immediate remedial results to that patient?
(3.00)

A. Eating a chocolate bar.
B. Drinking a solution of glucose.
C. Injecting glucose solution into a vein.
D. Injecting glycogen into a vein.
E. Drinking sweetened tea.

200. An individual suffering from infected tonsils often experiences a swelling of certain lymph nodes in the neck region. Such swelling may be due to
(3.00)

A. an accumulation of dead white blood cells or secondary infection.
B. a disturbance in hormone secretion.
C. an anemic condition brought on by the infection.
D. erythrocytosis. **E.** deranged protein metabolism.

201. If an individual's basal metabolic rate is considerably higher than normal, a reasonable hypothesis would be that
(3.00)

A. he is an alcoholic. **B.** he habitually overeats.
C. there is oversecretion of insulin into his blood stream.
D. he is past 45 years of age.
E. his thyroid gland is overactive.

202. When an individual loses as much as a quart of blood, excretion of urine and perspiration decrease sharply in amount. The occurrence of this phenomenon can best be evaluated by which one of the following?
(3.00)

A. Normal excretory functions will be restored when the abnormally high blood pressure is again reduced to normal.
B. Protein metabolism and urea formation are temporarily halted.
C. Nerve shock temporarily halts certain body functions.
D. Cellular respiration in the body stops until normal function is restored.
E. These are compensatory reactions for maintenance of body water balance.

Items 203 - 211 are concerned with the interpretation of the following passage:

A substance in human milk, the identity of which still is unknown, has been established as a destroyer of the virus of poliomyelitis. That report comes from Dr. Albert Sabin, director of infantile paralysis research in the Cincinnati, Ohio, Children's Hospital. Dr. Sabin said studies are being continued in an effort to learn just what the substance is. Dr. Sabin said one thing which led to the discovery of the properties of human milk was the experience in a polio epidemic last year in a Canadian Eskimo settlement. There were 275 cases of the disease. Twenty per cent of the victims became paralyzed and 14 per cent died but in no case did a child under 3 years old, when Eskimo children normally are being nursed by their mothers, become paralyzed. He said it first was determined that immunity with which all babies are born was not the contributing factor. Then it was found that human milk coats the mouth, throat, and digestive tract to set up a barrier to the polio virus. That was of particular importance since it is by way of the mouth that the polio virus enters the human system. Continuing the studies, 30 Cincinnati mothers were asked to give both blood and milk specimens. The human milk was mixed with polio virus and injected into mice. Mice receiving the mixture survived without paralysis while those which were inoculated with only polio virus developed paralysis.

—Minneapolis Star. May 19, 1950.

203. (3.00) Which one of the following constitutes the best statement of the problem inherent in the above passage?

- **A.** Why is polio less prevalent among Eskimos than among temperate zone dwellers?
- **B.** What is the effect of the polio virus on mice?
- **C.** What is the extent of polio in Eskimo children under 3 years of age?
- **D.** What is the effect of human milk on polio virus?
- **E.** How does the number of polio cases in Eskimo children under 3 years of age compare with the number of polio cases in Eskimos who are older than 3 years?

Items 204 - 211 are also based upon the foregoing passage. For each of these items mark space

- A if the item is a conclusion which the data tends to support.
- B if the item is a conclusion which the data tends to refute.
- C if the item is a conclusion which is irrelevant to this particular data.
- D if the item is not a conclusion, but a mere restatement of some of the data.
- E if the item is not a conclusion, but a definition.

204. (3.00) Human infants are born with a natural immunity to most bacterial disease.

205. (3.00) Bottle-fed babies are more likely to contract polio than are babies nursed by their own mothers.

206. (3.00) Fifty-five of the 275 Eskimo polio victims studied became paralyzed.

207. (3.00) Newborn Eskimo babies are immune to polio.

208. (3.00) Polio is a disease that is produced by a causative agent which manifests certain characteristics of life only when it exists parasitically within the body of another organism.

209. (3.00) Infants left by their mothers in the complete charge of professionally trained nurse maids who bring them up under conditions of modern sanitation are less likely to contract polio than infants brought up in squalor nursed by their own mothers.

210. (3.00) Polio virus enters the human body by way of the mouth.

211. (3.00) Something present in human milk prevents paralysis from polio in mice and may have a similar effect in human infants.

Items 212 - 216 deleted.

Items 217 to 221 are designed to measure your ability to interpret data and use your knowledge of biological science in extending this data toward generalized conclusions. The data is adapted from two separate studies.

ACCIDENT CHARACTERISTICS AS RELATED TO DRINKING CONDITIONS OF DRIVERS IN RURAL ACCIDENTS—YEAR 1946
PREPARED BY MICHIGAN STATE POLICE, SEPTEMBER 26, 1947

Type of Accident	Driver had not been drinking	% of all accidents driver under the influence	Driver drinking but not under influence
Collision with			
Pedestrian	4.8	0.1	0.3
Other motor vehicle	53.1	5.2	6.9
Fixed object	2.8	0.3	.6
Left roadway	14.5	1.7	3.1
All others	5.8	less than 0.1	.7
	81.0%	7.4%	11.6%

COMPARISON BETWEEN ALCOHOL CONCENTRATIONS IN DRIVERS IN ACCIDENTS AND IN DRIVERS IN NORMAL DRIVING POPULATION

Amount of Alcohol in Blood	Driving Population Control Group*		Drivers Involved In Accidents**		Ratio Accident Group to
Percent	Number	Percent	Number	Percent	Control Group
No Alcohol	1538	87.9	144	53.4	.6
.01 - .06	133	7.6	39	14.2	1.9
.07 - .10	56	3.2	28	10.4	3.3
.11 - .14	16	.9	22	8.2	8.7
.15 and over	7	.4	37	13.8	33.1

* Cross section of Evanston drivers stopped at random at eight different locations during different days of the week and during different hours of the day.

** Cross section of drivers involved in personal injury accidents.

Note: The National Safety Council recommends that drivers showing more than 15% alcohol in blood be considered as "under the influence."

For items 217 - 221 mark the statements according to the key.

KEY

- **A.** Entirely and conclusively supported by the data.
- **B.** In contradiction to the data.
- **C.** Neither supported nor contradicted by the data.
- **D.** Supported by the data and biological science permits the extension to a generalization.
- **E.** Supported by the data but biological science does not permit the extension to a generalization.

217. (3.00) To the extent that Evanston and Michigan drivers accurately represent our nation's total driving population, it can be concluded that an "under the influence" driver is more lacking in judgment and muscular coordination than normal drivers.

218. (3.00) If the data regarding Evanston drivers is directly applicable to Michigan drivers, a "had been drinking driver" in Michigan had over twenty times as many accidents in 1946 as the "no alcohol in blood" driver.

219. (3.00) Alcohol when taken into the body impairs the judgments and muscular coordination of an individual.

220. (3.00) If an automobile accident occurs at the intersection of two state highways in Michigan, it is an even chance that one of the drivers was either of the "had been drinking" or "under the influence" classification.

221. (3.00) A citizen of Evanston driving in Michigan during 1946 increased his chances of being involved in an accident over fifty times by "driving under the influence."

Questions 222 and 223 deal with a biologist who wanted to determine the effect of alcoholized water on the weight of rats by adding 10% of alcohol to their drinking water.

222. (3.00) Here is a set of procedures which he might follow. Find the one he would *not* use.

A. Take two dozen rats of approximately the same age, health and heredity.
B. Divide the rats into equal groups.
C. Keep them in the same large cage provided with drinking bottles containing both pure and alcoholized water.
D. Give the same quantity of food to each rat in both groups.
E. Weigh each rat every week.

223. (3.00) Here is another set of procedures. Find the one he would *not* follow.

A. Record the weights carefully.
B. Proceed with the experiment for several months.
C. Compare the health and vigor of the rats in the two groups.
D. Compare the weights of the rats in the two groups.

A dean of students, in seeking the effects of rest on grades, selected two groups of students; those who slept at least 8 hours every night and those who got less than 8 hours sleep. He found that those who slept 8 hours had higher grades than those who slept less than 8 hours. Questions 224 through 229 give possible conclusions from this experiment. Mark

A if the data given support the conclusion.
B if the data given are inadequate to support the conclusion.
C if the data given contradict the conclusion.

224. (3.00) Less than 8 hours sleep is associated with relatively lower grades in this group.

225. (3.00) Both low grades and less than 8 hours sleep are probably related to sociability.

226. (3.00) Less than 8 hours sleep is harmful to grades.

227. (3.00) At least 8 hours sleep is necessary for effective intellectual work.

228. (3.00) There is no demonstrable relationship between grades and amount of sleep.

229. (3.00) Low grades probably lead to long study hours and thus to less than 8 hours sleep.

230. (3.00) Two groups, each of 25 freshmen, were selected to be equal in general physical health. They were then fed carefully supervised diets, A and B. After 2 weeks on the special diets the 2 groups were put through a severe test of physical endurance. In the group fed diet A, 11 students failed; in the group fed diet B, 14 students failed. On the basis of the facts presented, what may be concluded about diet A?

A. Diet A is better than diet B.
B. Diet A is not better than diet B.
C. Diet A is about as good as diet B.
D. Diet A may or may not be better than diet B.

231. (3.00) It is common observation that flies and ants often feed upon molasses, candy, honey and overripe and decaying fruits. Flies and ants were observed to be attracted in unusually large numbers to the urine of a certain dog. Clinical examination of the dog would probably reveal

A. an overactive pituitary gland.
B. under secretion of adrenalin.
C. over secretion of thyroxin.
D. under secretion of secretin.
E. under secretion of insulin.

232. (3.00) The three children in family A are being brought up under home conditions where high standards of sanitation prevail, while the three children in family B constantly live and play in dirty surroundings with playmates from homes where low standards of sanitation also exist. As a consequence

A. the children from family A may be more susceptible if exposed to contagious disease than the children from family B.
B. the children from family A will probably have a higher resistance to contagious disease than the children from family B.
C. there is likely to be no difference in degree of susceptibility or resistance to disease in the children of the two families.

233. (3.00) This may be explained by the fact that

A. frequent light exposures stimulate antibody production and partial immunity.
B. sanitation makes the body strong and increases natural resistance.
C. when a contagious disease is on the increase all types of individuals are equally subject to it.

234. (3.00) To diagnose diabetes which one of the following tests would yield the most meaningful evidence?

A. Urine sample—iodine.
B. Urine sample—Benedict's solution—heat.
C. Urine sample—nitric acid—heat—ammonium hydroxide.
D. Blood sample—sodium oxalate; allow to stand 20 minutes.
E. Blood sample—pryogallic acid.

235. (3.00) A certain medicine, according to the attached label, will cure or mitigate diabetes. Which one of the following statements would best appraise the use of this medicine in connection with diabetes?

A. Since diabetes is caused by a deficiency of a digestive enzyme secreted through the pancreatic duct into the intestine, no medicine will cure diabetes.
B. Since diabetes is hereditary, it can be cured only by sterilization.
C. Diabetes is due to a hormone deficiency; it is unlikely that any medicine now known will cure this condition.
D. Since diabetes is more severe in old age, medicine might at best be expected to cure only youthful patients and to a limited extent alleviate the disease in older persons.
E. None of the above statements apply; since every case of diabetes is unique, no generalization is applicable.

236. (3.00) During the North African campaign approximately 97 of every 100 wounded brought to our evacuation hospitals survived the ordeal of their injuries. Only 83%

were saved in the first World War. The following reason was officially credited:

A. dried blood plasma. **B.** good surgery.
C. penicillin and sulfonamide drugs.
D. rapid evacuation of wounded.
E. immunity from contagious disease.

For items 237 - 245 read the following selection carefully. It is adapted from *Parade* Magazine, November 26, 1950.

Dr. John C. Calhoun has spent a year observing mice awake and asleep, at work and at play in "Mouse City." He has found that under certain conditions the behaviour of mice gives him a clue of what to expect from human beings.

At "Mouse City," Dr. Calhoun built apartments for families of both aggressive and non-aggressive mice. Then he watched them as they sought the everyday needs of mice and men; food, water and a place to live.

He discovered that mice develop different degrees of tolerance toward each other, depending on the genetic strain. In some strains all members live happily without serious fights over food, water or lodging. Other strains obviously don't like each other. They fight all the time, usually for the privilege of being ahead of the other fellow. A mouse is often chased from his feeding by an intruder when there is plenty of room for both of them.

In "Mouse City" Dr. Calhoun built "stairways" leading to each of the four floors of his apartment houses. Weaker mice were chased up to the top floor apartments by their stronger and more aggressive brothers, and lived in an inferior social world. Those that occupied apartments near the source of water and food became "Mouse City's" social leaders.

"If this pattern proves to be the general rule," says Dr. Calhoun, "it will mean that mice of different social rank move through their environment in different ways."

Directions: For items 237 - 245 select the best answer and mark the corresponding space on the answer sheet on the right of the item number.

237. (3.00) The statement, "He has found that under certain conditions the behavior of mice gives him a clue of what to expect from human beings" is

A. one which reflects a position that a scientist might take.
B. one which reflects a position such as no scientist would take.
C. one based on a false assumption that men and mice have basically similar behavior.
D. valueless because you can only learn about people by experimenting with people.
E. valueless because you cannot place mice under conditions corresponding to those under which human beings live.

238. (3.00) The statement in item #237 is based on the concept that

A. all life arises from pre-existing life.
B. all living matter consists of protoplasm.
C. all living organisms consist of cells or the products of cells.
D. man is an animal related to other animals.
E. animals differ from man in that they lack his highly developed nervous system.

239. (3.00) The statement in item #237 is further based on the concept that

A. mammals have many characteristics in common.
B. human society contains all kinds of people.
C. human social forms have arisen through evolution.
D. mice and human beings are basically different both physically and mentally.
E. man has a more highly developed brain than a mouse.

240. (3.00) The statement in item #237 is further based on the assumption that

A. one can achieve acceptable results only through experimentation.
B. under similar conditions comparable results may be expected.
C. anything a scientist does may be accepted as valid.
D. scientists generally work on problems that lead to social betterment.
E. observation may be substituted for experimentation.

241. (3.00) The statement, ". . . that (all) mice develop different degrees of tolerance toward each other, depending on genetic strain," is

A. an observation.
B. a generalization based on observation.
C. evidence in support of a generalization.
D. an assumption.
E. evidence in support of an assumption.

242. (3.00) The statement in item #241, if accepted as true and read in context with the remainder of the article, indicates that

A. heredity plays no part in determining the social behavior of mice.
B. environment plays no part in determining the social behavior of mice.
C. heredity interacts with environment in determining the social behavior of mice.
D. it is impossible to determine whether or not environment enters into the determination of social behavior of mice.
E. it is impossible to determine the part that heredity plays in the determination of social behavior of mice.

243. (3.00) The statement, "A mouse is often chased from his feeding by an intruder when there is plenty of room for both of them," is

A. evidence in support of a generalization.
B. an hypothesis. **C.** an assumption.
D. a test proposed for an hypothesis.
E. an unrelated observation.

244. (3.00) The idea included in the statement, "If this pattern proves to be the general rule, it will mean that mice of different social rank move through their environment in different ways," could be tested most effectively by

A. repeating the same experiment with the same mice under the same conditions to see if the same relationship holds.
B. observing how human beings behave under the similar conditions with similar relationships.
C. observing mice in the wild under natural, uncontrolled conditions.
D. subjecting mice of known social rank to changed conditions to see if the same relationships hold.
E. repeating the same experiment with rats under the same conditions to see if the same relationships hold.

245. The statement "... mice (in general) of different social
(3.00) rank move through their environment in different ways" is

A. a tentative conclusion. **B.** an assumption.
C. an observation.
D. evidence in support of an hypothesis.
E. evidence in support of an assumption.

Items 246 - 252 are concerned with interpretation of the following excerpt from the Minneapolis Star.

"There has been a great deal of controversy concerning the use of hormone creams on the skin. For some time some members of the medical profession were afraid of them, fearing that they might produce skin cancer, and even now there is some difference of opinion.

It seems that the general trend now is toward approval and loss of fear as to bad results. I have no intention of entering this argument, for I am not qualified to do so but I do want to report facts, as I have found them, to you.

A well-known skin specialist, with whom I recently talked, feels that there is no evidence to indicate that these creams are harmful and that there is much evidence to the contrary. In fact, he believes that the future of cosmetics lies in this field. He explained just what hormone creams do.

They contain estrogen. As the skin becomes older the tissues lose some of their ability to hold water. Estrogen helps by increasing water retention power. In this way it minimizes wrinkles and sags.

Women long for some product which will maintain or achieve a semblance of youth. Estrogen creams certainly are not the whole answer but they do seem to be a step in the right direction. There are many such creams on the market and whether you use one is up to you and your physician. I have used one for several years now with no bad effect and with noticeable improvement."

—Josephine Lowman.

246. The main problem discussed in the article is
(3.00)

A. whether hormones remove wrinkles in human skin.
B. whether hormone cream has a bad effect on the individual.
C. whether estrogen is absorbed through the skin.
D. how to maintain a semblance of youth.
E. whether hormone creams are approved by the medical profession for cosmetic purposes.

247. The evidence for resolving the problem in this news-
(3.00) paper article is

A. objective. **B.** concrete evidence.
C. conclusive. **D.** interpolated. **E.** inadequate.

248. The results of personal use of the cream and their
(3.00) evaluation by the writer of this article are

A. based on unverified opinion.
B. not based on facts.
C. based on medical examination.
D. based on scientific evidence. **E.** objective.

249. If you wanted to test the value of the hormone cream
(3.00) experimentally, the most reliable way would be to

A. treat the wrinkles on one side of the face and leave the other side untouched (control).
B. use two individuals of the same age, sex, and number of wrinkles; treat one and not the other.
C. go to a research laboratory and have them test it on many animals.
D. treat one-half of a large group of similar individuals with cream containing estrogen and the other half of the group with plain cream.
E. try a patch test on the skin anywhere on the body.

250. The most acceptable authority in determining the value
(3.00) of the hormone cream would probably be

A. the writer of the article. **B.** a cancer specialist.
C. a doctor who treats skin diseases.
D. a medical doctor who is a general practitioner.
E. a hormone research scientist.

251. It can be inferred from this article that
(3.00)

A. only old women should use hormone creams.
B. anyone with wrinkles will benefit from the use of the hormone cream.
C. all hormone creams contain estrogen.
D. hormones produce cancer.
E. hormones are dangerous.

252. On the basis of this article the only conclusion, among
(3.00) the following, that is warranted is that

A. estrogen affects only the cells of the skin.
B. the writer has not entered into the argument.
C. the use of estrogen creams, instead of reducing the number of wrinkles, will actually increase the number.
D. since estrogen normally stimulates the thickening of the uterine lining, it is likely to produce bizarre effects on the face.
E. the advantages, limitations, and disadvantages of the use of estrogen creams are not yet well understood.

Questions 253 - 258 deal with the following selection.

The leader is not a disembodied entity endowed with unique characteristics. He is the leader only in terms of his functional relationship to the group. Therefore the part he plays in the total dynamic pattern of the group defines him as leader. He is a leader not because he is intelligent, skillful or original, but because his intelligence, skill or originality is seen as a means by the group members. He is a leader not because he is relatively imposing of stature, well dressed, fluent of speech, or from a higher socio-economic background, but because these factors tend to predispose group members to expect better means from their possessor.

The leader is followed because he promises to get, or actually gets his followers more nearly what they want than anyone else. If he does so, he will be followed be he small, insignificant looking and relatively speechless. In our culture we have some predisposition to expect people with certain characteristics to provide better means. Also certain characteristics such as intelligence may by and large in fact enable certain individuals to provide better means. However, the leader is a product not of his characteristics, but of his functional relationship to specific individuals in a specific situation. As a result, the variability of leaders' characteristics upsets all but the broadest statistical efforts at analysis.

253. Which of the following would best sum up the meaning
(4.20) of this selection?

A. The leader must be above all else a person of vision and integrity.
B. The characteristics which go into being a leader are so varied as to defy statistical analysis.

C. The leader must stand out from his associates as a symbol possessing certain unique characteristics.
D. A person is chosen as a leader when members of a group feel they have in him a better means toward their ends.
E. Possessing an imposing stature, being well-dressed, fluent of speech, or from a higher socio-economic background is of little importance in becoming a leader.

254. (4.20) What does the author mean by the term "functional relationship" in lines 2-3 and 20?

A. Being an active contributing member.
B. What the leader does and what the members of the group believe he does or can do that affects them.
C. The working knowledge of the leader.
D. Amount of participation in group activities.

255. (4.20) If a statistical study of a large group of leaders revealed that they were on the average two inches taller, possessed a higher I.Q. and came from a higher socio-economic background than the general population, how would the author interpret these facts?

A. These factors apparently are what most people feel will make a good leader.
B. The findings are the result of a statistical artifact and bear no relationship to leadership.
C. This can be taken as evidence that leaders are born and not made.
D. These factors are probably some of the characteristics which a leader must possess.
E. While interesting, these findings neglect those intangible attributes which in the final analysis define the true leader.

256. (4.20) According to this selection is it likely that persons could be chosen as a leader by sheer propaganda without ever having demonstrated his ability as a leader?

A. Yes, if the propaganda is convincing.
B. Highly unlikely since actions speak louder than words.
C. No, a person must have a functional relationship to the group first.

257. (4.20) James G. comes to the author of the selection with this problem: James is determined to become a leader in his political party. He has read every book he could find concerning leadership but after six months of conscientious study he finds himself still "just one of the group." How will the author of the selection explain James' failure to become a leader?

A. The members of the group do not yet think of James as someone who can help them achieve something they want.
B. James' ambitiousness has probably antagonized members of the group and created an atmosphere of suspicion and distrust.
C. Six months is too brief a period in which to develop the necessary rapport (mutual trust and confidence).
D. James probably lacks some quality (or qualities) usually considered characteristic of successful leaders.

258. (4.20) The death rate from diabetes has increased markedly within the past 25 years. This is true in spite of the fact that Dr. Banting and his associates in 1922 announced to the world a means of alleviating diabetes by the use of insulin and in spite of the fact that during the past quarter century many clinics have been established to help diabetics care for themselves. Four of the following statements are true and consistent with the above facts. One statement is untrue and inconsistent with the above trend. Select this untrue statement.

A. Diabetes strikes after 40 years of age more often than in youth.
B. Diabetes is an infectious disease.
C. The average longevity (life span) in the United States has been increased by bringing infectious diseases under control.
D. Diabetes, though incurable, can be alleviated by administration of insulin.
E. Those who have inherited a predisposing tendency to diabetes are now more likely to live long enough to transmit this factor to their offspring.

29. *Parasitism and Disease*

PARASITISM AND DISEASE

1. (1.10) Which of the following scientists developed a means of preventing rabies?

A. Linnaeus. **B.** Pasteur. **C.** DeVries.
D. Lamarck. **E.** Weismann.

2. (1.10) An example of a deficiency disease is

A trichinosis. **B.** smallpox. **C.** common cold.
D. tapeworm infection. **E.** scurvy.

3. (1.10) Of the following diseases which one is caused by a parasitic worm?

A. Trichinosis. **B.** Lockjaw.
C. Rocky Mountain Spotted Fever. **D.** Syphillis.
E. Ringworm infection.

4. (1.10) Which of the following would be the most likely cause of the disease rickets?

A. An inadequate amount of sleep.
B. Inheritance of a predisposing tendency to the disease.
C. Insufficient vitamin D in the diet.
D. A filterable virus borne in impure milk and water.
E. Frequent prolonged exposure to cold and dampness.

5. (1.10) Which one of the following diseases will be alleviated to some extent by exposure to sunlight?

A. Scurvy. **B.** Beriberi. **C.** Malaria.
D. Cancer. **E.** Rickets.

6. (1.10) Of the following diseases which one is most frequently caused by the bite of an insect?

A. Scurvy. **B.** Influenza. **C.** Asthma.
D. Pneumonia. **E.** Typhus fever.

7. (1.10) Which one of the following is a communicable disease transmitted from person to person by direct contact?

A. Cancer. **B.** Rabies. **C.** Yellow fever.
D. Chicken pox. **E.** Diabetes.

8. (1.10) An insect which carries a disease-producing organism from one host to another is known as

A. a commensal. **B.** an autosome. **C.** a chrysalis.
D. a saprophyte. **E.** a vector.

9. (1.10) Genes and viruses are related in that they

A. are both self-producing protein molecules.
B. both live parasitically within the nuclei of cells.
C. both produce normal reactions within cells.

10. (1.10) Diseases old to the race differ from new diseases in that they

A. tend to run their course quickly and, if not fatal, lead to a definite immunity.
B. tend to be chronic and long-lasting, non-fatal, and not leading to a definite immunity.
C. tend to be very severe and show a high percentage of fatality.

11. (1.10) A parasite species and its host species develop a relationship which makes them

A. more tolerant of one another the longer they are associated.
B. develop more violent reactions toward one another the longer they are associated.
C. eventually terminate their association so that the parasite species becomes free-living cells again.

12. (1.10) When a new disease attacks a population it is most severe

A. among children under 6 years of age.
B. among adolescents and young adults.
C. among middle-aged people.

13. (1.10) Penicillin and other antibiotics and sulfa drugs are most effective for

A. parasitic worms. **B.** viruses.
C. certain types of cocci (round bacteria).

14. (1.10) Drugs are generally more effective

A. for parasites of complex nature.
B. for parasites of simple nature.
C. for plant parasites than for animal parasites.

15. (1.10) New diseases have arisen most frequently among those caused by

A. parasites of simple body structure.
B. parasites of complex body structure.
C. free-living species which have recently become parasites.

16. (1.10) A venereal disease whose effects may be felt in brain, heart, and other vital areas is

A. gonorrhea. **B.** coronary thrombosis.
C. Bright's disease. **D.** hyptertension. **E.** dysentery.

17. (1.10) A type of tumor that is usually "cancerous":

A. benign. **B.** mole. **C.** malignant.
D. syphilitic. **E.** all of the larger ones.

True or False.

18. (1.10) An individual immunized against typhoid fever builds his own antibodies and is thus passively immune.

19. (1.10) An antigen is

A. a substance which when introduced into the body stimulates the production of an antibody.
B. an antibody.
C. a deposition of mineral salts in the walls of the veins.
D. a certain quantity of stored glycogen.
E. a thrombus.

20. (1.10) Malaria can best be brought under control by

A. immunizing everyone against it by means of "shots."
B. eradicating the anopheles mosquito.
C. requiring universal pasteurization of all milk sold.
D. cooking all meat thoroughly before eating it.
E. imposing strict quarantine and avoiding all contact with those who have malaria.

21. (1.10) When foreign proteins are introduced into the blood stream they cause the body to produce immunizing substances called antibodies. Following are examples:

A. antitoxins. **B.** opsonins. **C.** lysins.
D. antigens. **E.** agglutinins.

22. (1.10) Routine Wasserman or Kahn tests should be made before marriage, as positive diagnosis for

A. gonorrhea. **B.** tuberculosis. **C.** syphilis.
D. heart disease. **E.** malaria.

23. (1.10) Which one of the following is not included among the ten leading causes of mortality in the United States at the present time?

A. Poliomyelitis. **B.** Heart Disease. **C.** Cancer.
D. Accidents. **E.** Pneumonia.

24. (1.10) Which one of the following is caused by a fungus?

A Trichinosis. **B.** Mumps. **C.** Hookworm infestation.
D. Ringworm infection. **E.** Tetanus (Lockjaw).

25. (1.10) Which of the following human diseases is caused by a bacterium?

A. Tuberculosis. **B.** Ring worm. **C.** Gym itch.
D. Athletes' foot. **E.** Malaria.

26. (1.10) How does a man acquire a tape worm?

A. By eating tapeworm proglottids.
B. By eating beef which contains living larvae.
C. By eating Mollusks.
E. By eating tapeworm eggs.

27. (1.10) What causes the fever of malaria?

A. Toxins injected by the mosquito.
B. Stagnant water injected by the mosquito.
C. Material released from red blood cells, which are broken down by the malarial parasite.
D. None of the above.

28. (1.10) The most prevalent and widespread disease in the world today is

A. typhoid fever. **B.** bubonic plague.
C. infantile paralysis **D.** malaria. **E.** influenza.

Items 29 - 33. Names of structures:

A. Cercaria. **B.** Proglottid. **C.** Seminal receptacle.
D. Seminal vesicle. **E.** Statocyst.

To which of the above do the following refer?

29. (1.10) Larval stage of fluke.

30. (1.10) Organ of equilibrium.

31. (1.10) Organ for sperm storage in female.

32. (1.10) Organ for sperm storage in male.

33. (1.10) Segment of tapeworm.

34. (1.20) For which of the following diseases has no means of preventive immunization as yet been developed?

A. Diphtheria. **B.** Smallpox. **C.** Tetanus (Lockjaw).
D. Tuberculosis. **E.** Typhoid fever.

35. (1.20) From a consideration of the habitat and life cycle of the tapeworm one would expect the adult worm to have

A. a well developed reproductive system.
B. well developed organs of sense.
C. functional organs for locomotion.
D. a normally developed digestive system.
E. glands secreting ptyalin.

36. (1.20) In the progressive effect of syphilis on the body which of the following represents the most advanced stage?

A. Partial paralysis of the nervous system.
B. Contraction of the disease. **C.** Inflamed eyelids.
D. Latent period. **E.** Formation of chancre or sore.

37. (1.20) Of the following, the one believed *not* to be a vector of disease is the

A. flea. **B.** wood tick. **C.** tapeworm.
D. louse. **E.** house fly.

38. (1.20) Which of the following diseases is *not* directly transmissible from person to person?

A. Influenza. **B.** Malaria. **C.** Scarlet fever.
D. Whooping cough. **E.** Tuberculosis.

39. (1.20) The quick freezing of foods is an effective way to

A. destroy bacteria without decomposing the food.
B. destroy bacteria with minor change in the form and caloric value of foods.
C. destroy bacteria with minimum altering of the vitamin content of foods.
D. reduce bacterial growth in foods that are harmed by sterilization.
E. totally stop bacterial action as long as temperatures below freezing are maintained.

40. (1.20) Allergies are most closely associated with

A. the production of toxins by bacteria.
B. a modification of the antigen-antibody reaction.
C. transmission of characteristics by heredity.
D. disturbances between the interrelated endocrine glands.
E. abnormal mental associations between objects or materials and malfunctioning of the lymphatic system.

41. (1.20) Of the following insects, which could most easily be killed by using poison bran mash?

A. Trichina. **B.** Grasshoppers. **C.** Hen lice.
D. Aphids. **E.** Chinch bugs.

42. (1.20) Because

A. they have sucking mouth parts.
B. they have rasping mouth parts.
C. they have huge pincers.
D. they have chewing mouth parts.
E. they lie down and roll in their food.

43. (1.20) Pasteurized milk is so treated that

A. all microorganisms are destroyed.
B. most non-spore-forming bacteria are destroyed.
C. it is sterile. **D.** it can be sold as Grade A milk.
E. it has become homogenized.

44. (1.20) An example of inoculation resulting in passive immunity is

A. injection of anti-toxin for diphtheria.
B. vaccination for smallpox.
C. immunization for typhoid.
D. immunization against influenza.
E. immunization against yellow fever.

45. Probably the greatest single advance in man's control
(1.20) of disease was marked by

A. the discovery of penicillin and the related biotic pharmaceuticals.
B. the development of the sulpha drugs.
C. Joseph Lister's development of antiseptic surgery.
D. public health laws requiring quarantine of patients with communicable diseases.
E. Pasteur's overthrow of the theory of spontaneous generation.

46. In general, artificial immunization is based on injecting
(1.20) into the body

A. foreign proteins that stimulate the production of antibodies.
B. substances that increase the number and potency of the white blood cells.
C. weakened organisms that cause the specific disease for which immunity is being established.
D. hemolytic, bacteriolytic, or phagocytic substances to aid the white corpuscles.
E. blood serum from an individual who has survived the disease.

Items 47 - 51. The human body may defend itself against disease by having one of the following kinds of immunity:

A. Natural immunity. **B.** Artificial active immunity.
C. Artificial passive immunity.

Before each of the following described disease situations write the number of the type of immunity which you think applies.

47. ______It is probable that many adults who have never had the "children's diseases" are nevertheless at least partly immune to them by frequent exposure insufficient to make them ill.

48. ______Serums are used in giving inoculations to pre-
(1.20) vent tetanus or diphtheria after the person has already been exposed.

49. ______The death rates of Jewish people from tuber-
(1.20) culosis and the Chinese people from scarlet fever are very low.

50. ______In 1939 Zinsser announced that he had succeeded
(1.20) in producing a vaccine for the prevention of typhus fever, a vermin borne disease that is a serious menace to armies. The antibodies which the vaccine stimulates the body to produce, counteract the typhus fever organisms.

51. ______An African native living in a highly malarial dis-
(1.20) trict is apparently in good health in spite of having harbored malaria parasites approximately from birth.

52. How is smallpox prevented by vaccination?
(1.20)

A. The virus used in vaccinating kills all smallpox germs that enter the body.
B. The virus used in vaccinating causes the body to produce strong antibodies.
C. The virus used in vaccinating changes to antibodies.
D. The antibodies used in vaccinating destroy all smallpox germs.

53. Of the following, the one which cannot be grown out-
(1.20) side of living cells is

A. bacterium. B. virus. C. fungus.
D. protozoan parasite. **E.** parasitic worm.

54. Which of the following does *not* describe a way in
(1.20) which antibodies combat antigens?

A. Some antibodies dissolve foreign tissues.
B. Some antibodies assist the action of white corpuscles.
C. Some antibodies prevent the dispersal of bacteria.
D. Some antibodies neutralize bacterial toxins.
E. Some antibodies stimulate the growth of antigens.

55. In the following pair, blacken space 1 if the first ele-
(1.20) ment of the pair is definitely greater than the second; space 2 if the second is definitely greater than the first; and space 3 if the two are approximately equal.

A. Resistance of bacterial spores to destruction by heat.
B. Resistance of vegetative forms of bacteria to destruction by heat.

Items 56 - 59 are diseases which afflict man. Use the key below to indicate the cause of each.

KEY

A. Vitamin deficiency.
B. Malfunctioning of one of the endocrine glands.
C. Bacteria or bacterial products. **D.** Protozoans.
E. Spirochetes.

56. Malaria. **57.** Cretinism.
(1.20) (1.20)

58. Syphilis. **59.** Tuberculosis.
(1.20) (1.20)

60. An insect vector is most frequently responsible for the
(1.20) transmission of which one of the following diseases?

A. Scurvy. **B.** Bubonic plague. **C.** Asthma.
D. Pneumonia. **E.** Athlete's foot.

61. Which of the following diseases is *not* directly trans-
(1.20) missible from person to person?

A. Tuberculosis. **B.** Influenza. **D.** Diabetes.
D. Whooping cough. **E.** Scarlet fever.

62. All except which one of the following are commonly
(1.20) recognized arthropod vectors of disease?

A. Mosquito. **B.** Flea. **C.** Cockroach.
D. House Fly. **E.** Louse.

63. When a new pathogenic disease is discovered, it is
(1.20) important to determine what organism causes it. Four of the five statements below are essential to establishment of proof that a certain specific microorganism is the cause of a given disease. One of the statements is irrelevant, that is, it is not essential to the proof. Select the one statement that is irrelevant and mark the corresponding answer space. The research scientist must

A. always find the organism in the blood of tissues of individuals who have the disease.
B. determine whether the organism is a plant (bacterium, yeast, mold) or an animal (protozoan, spirochete, trypanosome).
C. cultivate and isolate the organisms in an artificial medium, excluding all other forms of life.
D. produce the disease in typical form by inoculation of organisms from the culture into an experimental animal—man or beast.
E. find the same organisms in the blood or tissues of the experimental animal.

64. (1.20) A disease among the following that is not caused by a virus is

A. tuberculosis. **B.** chickenpox. **C.** common cold.
D. measles. **E.** rabies.

65. (1.20) The trichina worm life cycle is represented by which of the following?

A. Eggs pass from the host into water where they are ingested by snails and undergo several stages of development in the snails' bodies. At one of these stages they leaves the snails, bore into and encyst themselves in the flesh of fresh water fish. Man becomes infected by eating raw or improperly cooked fish.
B. The eggs are laid in the blood vessels of the walls of the intestine or bladder. Some are accidentally carried to the liver or lungs where they set up inflammation. The alternate stages occur in the bodies of snails.
C. The worm is anchored in man's intestinal tract where it absorbs digested food from man's alimentary tract. The proglottids or bags of eggs pass out of man's body and some may be eaten by a cow or a pig, the eggs which hatch are inside the new host's body eventually forming bladder worms in the muscle tissue of the host. Man's digestive enzymes may liberate the bladder worms which undergo further development in man's body.
D. This small worm is carried onto the skin by a mosquito when it bites a person. The worms penetrate the skin and obstruct the lymph channels causing certain parts of the body to swell to enormous proportions.
E. This worm lives as an adult in the intestinal tract of the hog. The young born here migrate to certain muscles where they encyst. Man acquires the worm by eating poorly cooked pork. The encysted larvae are freed by digestive enzymes and lodge in the muscles of man where they set up severe inflammation.

66. (1.20) When the causative organism of diphtheria enters the human body and begins to invade the body tissues it produces a poisonous substance which, in turn, stimulates the body to produce a counteracting substance. The poisonous substance in this case is classified as a (an)

A. antibody. **B.** virus. **C.** inhibitor.
D. antigen. **E.** anti-toxin.

Items 67 - 78. After each item number on the answer sheet, blacken space

A if the item pertains to one or more kinds of filterable viruses.
B if the item pertains to one or more kinds of bacteria.
C if the item pertains to parasites in general.
D if the item pertains to living carriers.
E if the item is true of none of the above.

67. (1.20) These organisms require living organic matter from their environment in order to be sustained.

68. (1.20) Minute one-celled microscopic plant-like organisms which multiply by fission and lack chlorophyll.

69. (1.20) Are not visible under the ordinary microscope and behave like parasites within the cells of other organisms.

70. (1.20) Transmits scurvy to infants.

71. (1.20) An agent that transfers bacteria or protozoa directly from one human host to another.

72. (1.20) Ultramicroscopic organisms known to grow only in the presence of living cells and which apparently survive freezing.

73. (1.20) Produces tetanus or lockjaw.

74. (1.20) Capable of producing a simple goiter.

75. (1.20) The antitoxin provides passive immunity.

76. (1.20) Any organism which lives in another living organism, from which it derives nourishment at the expense of the latter.

77. (1.20) Antibodies may cause these bodies to clump.

78. (1.20) The process of pasteurization is employed to destroy these organisms.

Items 79 - 92. After each item number on the answer sheet, blacken space

A if the item refers to hereditary immunity.
B if the item refers to active acquired immunity.
C if the item refers to passive acquired immunity.
D if the item refers to susceptibility.

79. (1.20) The factor is present at fertilization.

80. (1.20) Acquired through actually contracting the disease such as diphtheria; the person produces his own antitoxin.

81. (1.20) Resulting from the injection of an attenuated or weakened antigen.

82. (1.20) The vaccine stimulates the body tissues to react and produce antibodies.

83. (1.20) The infant receives immunity from the mother's milk.

84. (1.20) The body tissues lack resistance to a disease.

85. (1.20) This type of resistance is short-lived, lasting only a few weeks or months.

86. (1.20) Many communicable diseases can be controlled by using the serum of vaccinated animals.

87. (1.20) People lack protective substances for venereal diseases.

88. (1.20) Immune serum for diphtheria contains specific antitoxins to lessen the clinical symptoms for the disease.

89. (1.20) Birds do not get human malaria.

90. (1.20) The infant receives immunity from the mother through the placenta before birth.

91. (1.20) The injection of antibodies results in this type of immunity.

92. (1.20) Resulting from the injection of heat-killed typhoid bacteria.

Items 93 - 102. After each item number on the answer sheet, blacken space

A if the item is true of active immunity.
B if the item is true of passive immunity.
C if the item is true of both types of immunity.
D if the item is true of neither type of immunity.

93. (1.20) This immunity may be secured following the injection of antibodies.

94. (1.20) This kind of immunity may be obtained through the injection of specific antigens.

95. (1.20) This type of immunity generally follows the successful recovery from certain infectious diseases.

96. (1.20) This kind of immunity can be obtained through the injection of serum from the blood of a patient recovering from the specific disease.

97. (1.20) This is the type of immunity acquired through the use of a vaccine prepared from dead or weakened bacteria.

98. (1.20) Antibodies passing from the blood of the mother to the blood of the embryo provide the infant with this kind of immunity.

99. (1.20) This type of immunity is not of long duration, generally not more than two or three weeks.

100. (1.20) This is an acquired type of immunity.

101. (1.20) The injection of a toxin extracted from a pure culture of bacteria may induce this type of immunity.

102. (1.20) This kind of immunity may be had following the injection of an antitoxin.

Items 103 - 112. After each exercise number on the answer sheet, blacken space

A if the item refers to antigens.
B if the item refers to antibodies.
C if the item refers to *both* antigens and antibodies.
D if the item refers to *neither* antigens nor antibodies.

103. (1.20) A knowledge of these is essential in the treatment of diseases of microbial origin.

104. (1.20) Pollens of ragweed and goldenrod are frequently causative agents of allergies.

105. (1.20) Some of these substances bring about a clumping of bacteria.

106. (1.20) Are injected in the form of a weakened virus to secure active immunity from smallpox.

107. (1.20) Such substances include living or dead bacteria, their products, or other foreign proteins.

108. (1.20) Antitoxins belong to this group of substances.

109. (1.20) Are injected into animals in order to produce blood serums useful in creating passive immunity in human beings.

110. (1.20) Are injected into the body in order to produce immunity from all diseases produced by bacteria.

111. (1.20) One explanation of the natural immunity of infants assumes that such substances are transferred from mother to child through the placenta or through mother's milk.

112. (1.20) Toxins or toxoids belong to this group of substances.

Items 113 - 123. A biological situation is given below. Following is a list of items, each of which may or may not be related to the situation. After each item number on the answer sheet, blacken space

A if the item explains the cause of the situation.
B if the item describes the situation.
C if the item gives the effect of the situation.
D if the item is true but not related to the situation.
E if the item is false.

Situation: Vaccination results *in active immunity against smallpox.*

113. (1.20) The antitoxins of serums neutralize toxins.

114. (1.20) Active immunity protects an individual from subsequent contraction of the disease.

115. (1.20) Active immunity is usually a temporary immunity of short duration.

116. (1.20) Smallpox vaccine contains a weakened form of the smallpox virus capable of producing active immunity against smallpox.

117. (1.20) An individual produces his own antibodies.

118. (1.20) A small amount of the material from a smallpox sore of a patient with a mild case rubbed into a slight wound in the skin may serve as a vaccine.

119. (1.20) Antigens stimulate the body to produce antibodies.

120. (1.20) Toxins may be used as antigens.

121. (1.20) Smallpox antibodies neutralize smallpox antigens and thereby create an immunity to smallpox.

122. (1.20) A specific antigen introduced into the body of man stimulates it to build antibodies.

123. (1.20) Antibodies have no effect in building up immunity.

124. (1.20) Which of the following provides evidence that most grown-ups have been carriers of some diseases that have gone unrecognized?

A. Adults have acquired immunity by mild exposure to many diseases to which children are highly susceptible.
B. Most people living in civilized countries have had at least one or more vaccinations during their lifetime.
C. Man is the only organism that can deliberately immunize himself.
D. Many people have escaped illness in childhood and youth by living under highly sheltered and strictly sanitary conditions.
E. Most diseases do not have clear-cut symptoms and leave no noticeable after-effects.

125. (1.20) Of the following diseases which one is probably least prevalent in the United States?

A. Cancer. **B.** Influenza. **C.** Heart disease.
D. Infantile paralysis. **E.** Tuberculosis.

126. (1.20) Bacterial population plays an important role in food spoilage and disease. This role is due primarily to the

A. action of bacteria in the food chain.
B. high biotic potential of bacteria.
C. unique quality of bacterial metabolism.
D. low rate of photosynthesis.
E. absence of hormones in bacteria.

For items 127 - 135 select from the following key the statement which best applies, then mark the corresponding answer space.

KEY

A. First part of statement is true; second part is false.
B. First part of statement is true; second part is true.
C. First part of the statement is false; second part false.
D. First part of statement is false; second part is true.

127. (1.20) Malaria is entirely a tropical disease and is caused directly by a protozoan.

128. (1.20) Typhoid fever is an infectious disease that is transmitted by bacteria that are consumed with contaminated milk and water.

129. (1.20) Antitoxins are protein substances and are produced in the host organism.

130. (1.20) The number of white cells in the blood stream decreases when an individual is suffering from appendicitis because the germs in the appendix leave and attack the spleen.

131. (1.20) The bread mold Neurospora is called a saprophyte because it lives on living organic matter.

132. (1.20) Nitrogen-fixing bacteria and clover live in a symbiotic relationship which is a relationship of mutual benefit.

133. (1.20) Adaptation to high altitudes will involve an increase in the number of red blood corpuscles and the mechanism bringing about the reaction is the stimulation of red bone marrow by low oxygen content of the blood.

134. (1.20) Carbon dioxide is a product of respiration in both plants and animals and is used in such plants as fungi in the process of photosynthesis.

135. (1.20) Stream pollution with raw sewage tends to reduce the fish population because the bacteria decomposing the sewage use the available oxygen supply.

Items 136 - 141 deleted.

Items 142 - 147 deleted.

148. (1.20) The diseases of man which may be contracted by drinking milk are either those transmitted from the cow or those derived from persons handling the milk. Examples are as follows:

A. undulant fever. **B.** typhoid fever.
C. tuberculosis. **D.** streptococcic sore throat.
E. pneumonia.

149. (1.20) A vaccine which contains microbes or their products

A. produces active immunity.
B. is slow in development.
C. is fairly permanent. **D.** contains antibodies.
E. is used almost exclusively in preventing a disease before exposure.

Item 150 deleted.

151. (1.20) Which of the five leading causes of death in the U. S. A. in 1900 stands apart from the others?

A. Tuberculosis. **B.** Pneumonia.
C. Diarrhea and enteritis. **D.** Heart disease.
E. Diseases of early infancy.

152. (1.20) Which of the five leading causes of death in the U. S. A. in 1940 stands apart from the others?

A. Heart Disease. **B.** Cancer. **C.** Apoplexy.
D. Pneumonia. **E.** Nephritis.

153. (1.20) An obstruction of the lymphatic vessels in the legs as in a tropical worm disease, elephantiasis, would cause

A. an increase in arterial blood pressure.
B. a swelling of the leg.
C. an increase in blood flow to the legs.
D. excessive drainage of tissues of the legs.
E. an increase of plasma proteins.

154. (1.20) All parasites share with their hosts a common

A. food supply. **B.** shelter and protection.
C. means of transportation. **D.** life history.
E. association.

155. (1.20) Which of the following food preservation methods does *not* depend upon killing the bacteria in order to prevent food spoilage?

A. Pasteurization.
B. Intermittent heating and cooling.
C. Fast-freezing. **D.** Salt brines or sugar syrup.
E. Smoke from burning wood.

156. (1.20) Immunity to a disease may be acquired by

A. all of the following. **B.** infants prior to birth.
C. injection of an antigen.
D. injection of antibodies.
E. surviving an attack of the disease.

Items 157 - 158 deleted.

159. (1.20) Which of the following is *least* likely to be found in animal parasites?

A. Impervious, tough cuticle.
B. Reduced muscular system.
C. Reduced nervous system.
D. Reduced reproductive system.
E. Suckers or hooks.

Items 160 - 171 deleted.

172. (1.20) The production of desirable antibodies is commonly stimulated, in man, by the injection of

A. serums. **B.** antitoxins. **C.** agglutinin.
D. toxin. **E.** antibiotics.

173. (1.20) The alternate host of the fungus causing Black Stem Rust of wheat is

A. cedar trees. **B.** native barberry bushes.
C. wild gooseberry bushes.
D. wild currant bushes. **E.** apple trees.

Items 174 - 178. Special kind of parasitism:

A. Parasitoidism.
B. Permanent obligatory endoparasitism.
C. Social parasitism.
D. Temporary obligatory ectoparasitism.

To which of the above do the following examples belong?

174. (1.20) Bedbug.

175. (1.20) Cowbird which lays its eggs in nests of other birds.

176. (1.20) Ichneumon wasps which lay eggs on caterpillars.

177. (1.20) Mosquito.

178. (1.20) Tapeworm.

Items 179 - 187. A parasite may get to a new host in many ways; some of these are listed.

- **A.** By active penetration.
- **B.** By contamination of food or water.
- **C.** By being associated with the food chain.
- **D.** By passive inoculation in association with a parasite chain.
- **E.** By other means.

Which of these methods is present in the following examples?

179. (1.20) Ameba of amebic dysentery in man.

180. (1.20) Hookworm of man.

181. (1.20) Malarial organism of man.

182. (1.20) Malarial organism of mosquito.

183. (1.20) Tapeworm of dog.

184. (1.20) Oviduct fluke of birds.

185. (1.20) Larval fluke of dragon fly.

186. (1.20) Larval tapeworm of rabbit.

187. (1.20) Larval fluke of snail.

188. (1.20) Which of the following would you expect to be least changed in an animal which has become an obligatory permanent endoparasite?

A. Digestive system. **B.** Excretory system.
C. Locomotor organs. **D.** Reproductive system.
E. Sense organs.

189. (1.20) The proportion of Drosophila eggs which develop to adulthood is

A. greater than **B.** less than **C.** same as
the proportion of Taenia eggs which develop to adulthood.

Items 190 - 202.

Below are given a number of statements dealing with immunity. The numbers in the blanks refer to the numbers on the answer sheet. If the term to fill in the blank refers to a substance or a kind of immunity, look for it in the list so headed, and blacken the appropriate lettered space on the answer sheet. Read each sentence completely before selecting the best terms to fill the blanks. (All 2.20)

Substances
- **A.** Serum.
- **B.** Vaccine.
- **C.** Antibodies.
- **D.** Antigen.

Kinds of Immunity
- **A.** Active.
- **B.** Passive.
- **C.** Permanent.
- **D.** Transient.
- **E.** Natural.

A **190** contains microbes or their products while a(n) **191** contains antibodies. A vaccine produces **192** immunity, slow in development but fairly **193**; a serum produces **194** immunity, immediate but **195**. A(n) **196** is used almost exclusively in preventing disease, before exposure; a(n) **197** is used as a preventive after exposure to infection or as a cure after the disease has developed.

In a disease like botulism or diphtheria the symptoms are due to a toxin which was produced by the specific pathogenic organism. A child suffering from diphtheria receives antitoxin **198**, which contains **199**. These substances should be administered early and in sufficient doses if they are to be successful. The use of diphtheria toxin or a toxoid vaccine protects susceptible individuals, acting as a(n) **200** in the blood stream where definite plasma proteins or **201** are produced resulting in the building up of **202** immunity against the disease.

Items 203 - 230. (All 2.20)

In an urban community such as Chicago there is a highly organized public health service. The many problems affecting our health require community activity for their solution. One cannot participate intelligently in their solution without a knowledge of the biological factors underlying them. A survey of some of the divisions of the Health Department of the city of Chicago will indicate the need for a knowledge of the underlying biological factors. Below are given a number of statements concerning the methods of disease control, causal agents of diseases, kinds of immunity, and chemical substances, which must be understood if we are to appreciate our public health functions and are to be active participants in a community health program.

The first number in each blank is the answer sheet number. The second, or Roman number, refers to the particular list below from which the correct answer is to be chosen. After each item number on the answer sheet, blacken the one lettered space to designate this correct answer.

I. *Agents Causing Disease*
- **A.** Filterable viruses.
- **B.** Bacteria.
- **C.** Other parasites.
- **D.** More than one of the above.
- **E.** None of the above.

II. *Substances*
- **A.** Antigen.
- **B.** Antibodies.
- **C.** Antigens and antibodies.
- **D.** More than one of the above.
- **E.** None of the above.

III. *Kinds of Immunity*
- **A.** Active.
- **B.** Passive.
- **C.** Natural acquired.
- **D.** More than one of the above.
- **E.** None of the above.

IV. *Methods of Control*
- **A.** Isolation.
- **B.** Quarantine.
- **C.** Immunization.
- **D.** More than one of the above.
- **E.** None of the above.

The Veneral Disease Section of our health department provides diagnostic tests for syphilis, a disease caused by **203-I.** There is no known control method of **204-IV** for syphilis. Smear tests for determining the presence of gonorrhea, a disease caused by **205-I** are also performed in this department. Many communicable diseases can be controlled by passive immunization, resulting from injection of **206-II. 207-II** can be injected into the bodies of animals, causing them to build **208-II.** Blood serum containing the latter can be introduced into the human body giving it **209-II** which will react immediately in conferring **210-III** immunity.

The Communicable Disease Section of the health department affords diagnostic X-ray and tuberculin tests for such diseases as tuberculosis which is caused by **211-I.** This disease has been intimately associated with the socio-economic status of an individual. It is fortunate that our public health facilities provide diagnostic tests as well as the following method of control 212-IV for active cases of tuberculosis. By contracting a mild form of the disease many people acquire 213-III immunity to tuberculosis.

We also learn in this department that there are tests to determine the susceptibility to such diseases as diphtheria and scarlet fever, both of which are caused by 214-I. In case of diphtheria control, a diphtheria toxoid is injected conferring 215-III immunity.

Cases of highly communicable disease reported to the Communicable Disease Section are referred for care to the Municipal Contagious Hospital, where the following method(s) of control 216-IV is (are) carried out. However, many cases of children's diseases, such as whooping cough, which only recently has been controlled by 217-IV, are also put under the control method of 218-IV in the child's home. Measles and chicken pox caused by 219-I are controlled in a similar manner. Even such non-prevalent diseases as hookworm, which is caused by 220-I, have been reported to this department from certain communities of our city.

There are inspectors of restaurants and food handling institutions reporting their findings to the health department. Diseases such as bacillary dysentery caused by 221-I are readily transmitted through improper food handling. Specific temperatures of food storage refrigerators, and dishwashing facilities are checked periodically by the inspectors, in an effort to reduce the possibility of incubation of certain disease producing agents such as 222-I. The important problem is the developing of community health consciousness in restauranteers and food handlers in general. Typhoid fever caused by 223-I and transmitted in both water and milk is no longer a disease of any importance in this area due to present effective control methods. 224-III immunity against typhoid fever is achieved by injection of heat-killed agents causing the disease.

Summer camp inspections are made by a division of the health department. Polio, a disease caused by 225-I and for which there is no effective method of 226-IV has been the subject of much research by this section. Where there has been an outbreak of this disease in camps the following method(s) of control 227-IV are taken. Vaccination against smallpox has long been a requirement for children, particularly when large numbers of them are brought together. Inoculation with the vaccine provides 228-III immunity.

In the Maternal and Infant Welfare Section, case studies are available, which have added much data concerning a type of 229-III immunity, which is explained on the basis of 230-II passing from the mother to the child through the placenta before birth.

Items 231 - 234.

Each of the items presents a brief description of an experiment followed by a conclusion drawn from the experiment. Use the most applicable statement of the key to evaluate the conclusion. Observations made during the course are to be considered factual in marking these items.

KEY

- **A.** The conclusion does not answer the problem prompting the experiment.
- **B.** The conclusion is not in agreement with the facts of the experiment.
- **C.** There are not enough facts revealed by the experiment to make the conclusion valid even though the conclusion is in agreement with biological science.
- **D.** Due to the lack of proper controls or other poor experimental technique, the observations from the experiment prompted a conclusion in disagreement with accepted biological science.
- **E.** The conclusion is tentatively justified.

231. (2.20) A student interested in frozen food preservation wanted to determine whether extremely low temperatures killed the kind of bacteria that spoil meat. He cut a piece of meat into two pieces leaving one piece at room temperature and the other in a locker at a temperature of 40 degrees below freezing. Both samples were sealed in a bacteria-proof container. After thirty days he opened the two packages. He found the room temperature sample badly decomposed. The second sample was in its original condition except for being frozen solid. Conclusion—A temperature 40 degrees below freezing will kill the bacteria that are responsible for the decay of meat.

232. (2.20) To compare the relative germicidal powers of two brands of mouth wash, A and B, a circle of filter paper was soaked in each brand and placed in the center of sterile culture dishes. The dishes were inoculated and then incubated for three days. Observation revealed a more extensive clear zone in the media treated with sample A. Conclusion—Disregarding cost, mouth wash A is a better germicide than mouth wash B.

233. (2.20) To prove that a specific person, A, was capable of transmitting a certain disease spread by a specific kind of contact, public health records were examined. It was learned that B, without similar contact with any other individual had acquired the disease after contact with A. C did not acquire the disease after similar contact with A. Conclusion—B is not capable of transmitting this disease.

234. (2.20) To study the rate of multiplication of flies, a milk bottle was prepared with food in the bottom and five flies of each sex placed in the bottle. Every eighth day the flies in the bottle were counted. The data follow:

Day	Number
1	10
8	500
16	25000
24	28000
32	29000

Conclusion—Flies in a limited environment will multiply at an ever increasing rate.

Items 235 - 246 are based upon the following situation and certain fundamental principles of disease transmission.

Hookworm breaks out in a coal mining community located in a sub-tropical region.

The following facts are reliable concerning conditions found within the community.

- **A.** The central water supply is not chlorinated but is drawn from what appears to be an uncontaminated source. When tested at regular but not frequent intervals it meets hygienic requirements.
- **B.** A number of residents do not use the community central water supply but drink well water from shallow wells. This water is not tested for pathogenic organisms.
- **C.** Those most heavily infected with hookworm are certain of the male adults, the women and children largely escaping.

D. The climate is warm and moist throughout most of the year.
E. The grocery stores are not screened and flies are very common on the fruit and many other unprotected foods.
F. The clerks in these grocery stores are usually male.
G. Although the climate is warm the adults, including those of the poorer classes, wear shoes.
H. The children often do not wear shoes.
I. Meat sold in some of the stores is uninspected. It comes from local farms where it is slaughtered.
J. Modern plumbing is quite universal within the community.
K. Mosquitoes are very prevalent, especially in the swampy valley in which the tunnels to the mines are opened.
L. Plumbing facilities are available in many but not all portions of the mines.
M. Rats infested with fleas are found in large numbers in the community dump on the outskirts of the town.
N. The community itself is clean, garbage being collected at frequent intervals and sewage is adequately disposed of.
O. The miners bring their lunches to work. They sit down to eat in the mine tunnels in groups during their lunch hours.

For items 235 - 246 mark

A if both the statement and the reason for it are probably true.
B if the statement is probably true but the reason is probably false.
C if the statement is probably false but the reason following it is an accepted scientific fact or principle having no bearing upon the statement.
D if the statement and the reason for the statement are both probably false.

235. (3.00) The hookworm infections were caused by the mosquitoes along the mine's entrance, *because* mosquitoes are known to be the vectors of certain roundworm diseases.

236. (3.00) The hookworm infections were caused by uncooked pork in the miners' lunches, *because* uncooked pork is known to contain at times live (encysted) trichina worms.

237. (3.00) Hookworm is not usually found in northern communities, *because* winters kill the larvae in certain stages of development.

238. (3.00) The majority of men infected are those working as clerks in the grocery stores, *because* they continually handle fruit and other foods on which flies swarm.

239. (3.00) The majority of the men infected are those working in the mines, *because* their habit of congregating to eat lunch provides an excellent opportunity for the spread of the disease.

240. (3.00) The majority of the men infected are those working around the community dump, *because* certain rat fleas are known vectors of disease.

241. (3.00) The majority of men infected are those working around the community dump, *because* the rats, themselves, commonly harbor hookworm.

242. (3.00) The hookworm is contracted by those drinking water from untested wells, *because* it is a known fact that hookworm is commonly spread by infected water and milk supplies.

243. (3.00) The majority of men infected are those working in the grocery stores, *because* they are handling uninspected meat which might well contain hookworm larvae in an infected stage within the muscle tissue.

244. (3.00) The majority of the men infected are those working in the mines, *because* human fecal material containing hookworm larvae is occasionally deposited in the mine tunnels, the larvae being carried along the mine tunnels by water to places where they are acquired by the miners while the miners are sitting down to rest or lying down to carry on mining operations.

245. (3.00) Hookworm causes muscular soreness, *because* the larvae encyst in the muscles of the infected individual.

246. (3.00) Hookworm causes lassitude and anemia in the patient, *because* the larvae, feeding upon epithelial tissue, secrete substances toxic to the infected individual.

Items 247 - 248 are based upon the following experimental data:

Dodder, an orange-colored parasitic plant, twines around other plants and obtains nourishment from them through tube-like outgrowths from the stem. If it is living upon a long-day plant, such as Calendula, it will flower only when the days are long. If it is living upon a short-day plant, such as Cosmos, it will flower only when the days are short.

247. (3.00) From the foregoing evidence, it can be tentatively concluded that the dodder

A. is a long-day plant. **B.** is a short-day plant.
C. determines whether its host will be a long-day or a short-day plant.
D. has no stimulative effect on its host.
E. probably obtains growth hormones as well as food from its host.

248. (3.00) The evidence further suggests that

A. parasites usually destroy their host.
B. enzymes pass from host to parasite.
C. adjustment to a given day-length is fixed for all plants—a plant is either a long-day or a short-day plant.
D. a hormone produced in one plant can effect a change in another plant.
E. the dodder is a very wide-spread menace to crops in the United States.

249. (3.00) A wasp was seen feeding upon sap which had exuded from a slashed tree trunk and which had collected in a hollow niche where it was exposed to the air for several weeks. The wasp, when subsequently attempting to fly, careened about in the air seeming to have lost all ability to coordinate its movements. Which of the following might serve the best as a possible explanation?

A. This is the usual manner in which wasps fly.
B. The wasp had probably imbibed more sap than it could carry in flight.
C. Bacterial action may have changed the sap in some way.
D. Yeast spores may have had some effect on the sap during its several weeks' exposure to the air.
E. Certain bacteria change alcohol into acetic acid.

250. (3.00) To which one of the following diseases might a child be exposed if he went wading in a lake in Michigan?

A. Dysentery. **B.** Rickets. **C.** Scurvy.
D. Schistosomiasis. **E.** Beri-beri.

Items 251 - 254 are concerned with the following incident:

During dissection of a fresh-water fish a student found within the digestive tract a long, white, ribbon-like structure. The student observed that the structure was narrower at the attached end and wider at the free end. He formulated these hypotheses:

KEY

A. The structure was a blind sack-like extension of the intestine to increase digestive surface.
B. The structure was a free-living animal that the fish had eaten as food.
C. The structure was a parasitic worm living within the intestine of the fish.
D. The structure was an abnormal tumorous or cancerous growth.

251. (3.00) Closer examination revealed no adaptive structures that would have permitted the structures that would be able to carry on locomotion or digestion. This is sufficient to eliminate hypothesis or hypotheses,

A. A and B. **B.** B and C. **C.** B only.
D. C only. **E.** None of these.

252. (3.00) Additional examination of several other fish of the same species revealed that the same structure was absent. This is sufficient to practically eliminate hypothesis or hypotheses,

A. A and B. **B.** B and C. **C.** C and D.
D. A only. **E.** B only.

253. (3.00) Additional examination of the ribbon-like structure revealed no adaptive structures that would have permitted circulation or respiration. This in addition to the data in item 251, is sufficient to eliminate hypothesis or hypotheses,

A. A, B, C, and D. **B.** A only.
C. B and C only. **D.** C and D only.
E. D only.

254. (3.00) After all these observations the student had best conclude that the structure was

A. an extension of the intestine.
B. an animal eaten by the fish.
C. a parasitic worm. **D.** an abnormal growth.
E. a foreign object accidentally swallowed by the fish.

Items 255 - 262 are based upon the following situation:

A man went on a brief camping trip into the woods of Michigan in early summer. While on the trip he

A. shot and skinned a rabbit which was unable to run very fast.
B. drank untreated water from a stream.
C. drank unpasteurized milk offered him by a farmer.
D. found a tick taking blood from the back of his neck.
E. went wading in a lake without shoes or other protective covering on his feet and legs.
F. ate a practically raw hamburger at a roadside stand.
G. was bitten by Anopheles mosquitoes.
H. suffered a rather deep cut on his leg by catching his leg on a piece of projecting wire while climbing over a fence.
I. slept in a bed infested with bed bugs and lice.

255. (3.00) While on this trip it is quite certain that he did *not* acquire from the above experience

A. yellow fever. **B.** typhoid fever. **C.** malaria.
D. tularemia. **E.** undulant fever.

256. (3.00) It is quite possible that from the rabbit he could have acquired

A. tularemia. **B.** typhoid fever.
C. undulant fever. **D.** hookworm. **E.** cancer.

257. (3.00) He may have acquired from what he ate and drank

A. smallpox. **B.** dysentery.
C. African sleeping sickness. **D.** scurvy.
E. diabetes.

258. (3.00) He could also have acquired from the food

A. measles. **B.** undulant fever. **C.** chicken pox.
D. leukemia. **E.** *Pityrosporum ovale.*

259. (3.00) By wading in the lake he may have exposed himself to

A. typhoid fever. **B.** schistosomiasis.
C. undulant fever. **D.** Rocky Mountain spotted fever.
E. tetanus.

260. (3.00) From the cut on his leg, if not treated, he may have developed

A. schistosomiasis. **B.** tularemia.
C arteriosclerosis. **D.** tetanus. **E.** varicose veins.

261. (3.00) It is possible that he exposed himself on the trip to all except which one of the following?

A. Typhus fever. **B.** Tapeworm. **C.** Trichinosis.
D. Typhoid fever. **E.** Beri-beri.

262. (3.00) Of the following the one to which he did *not* expose himself by his experience was a

A. parasitic worm. **B.** protozoan disease.
C. Rickettsial disease. **D.** chronic disease.
E. bacterial disease.

Items 263 - 268.

A bacteriologist filtered a large colony of bacteria and obtained a bacteria-free material referred to as *raw substance K.* He determined the minimum lethal dose, i.e., the smallest amount of this *raw substance K* that was necessary to kill the experimental animal within three days. These animals (Group I) went through the characteristic clinical symptoms before death normally produced in infection caused by the living bacteria in question. He then subjected the *raw substance K* to a chemical and to heat and designated it as *treated substance K.* The scientist set up two large groups of animals which he called Group II and Group III. Group III received a large amount of *treated substance K.* The members of this group did not become sick. A few days later both Group II and Group III received the minimum lethal dose of the *raw substance K.* Within three days all of the animals in Group II died. Those of Group III went through the mild form of clinical symptoms of the disease and appeared normal by the fourth day and could not later be infected by the same kind of bacteria.

Blacken space

A if the item is true of *raw* substance K.
B if the item is true of *treated* substance K.
C if the item is true of both.
D if the item is true of neither.

(Be careful to make your judgments in terms of the data given in the description of the experiment.)

263. (3.00) The substance acted as an antibody.

264. (3.00) The substance acted as a toxin.

265. (3.00) The substance acted as an antigen.

266. (3.00) The substance acted similarly to diphtheria toxoid.

267. (3.00) The substance acted as a weakened toxin.

268. (3.00) The experiment performed upon the animals of Group III constitutes a process of

A. active immunization. **B.** passive immunization.
C. neither active nor passive immunization.

269. (3.00) The characteristics of five species of bacteria are listed as follows:

Organism A—Large rod-shaped, spore-former, motile, found in soil.
Organism B—Small, non-motile, occurs in packets of four, non-spore-forming.
Organism C—Short rods, motile, non-spore-forming, inhabit the intestine.
Organism D—Slender rods, non-motile, non-spore-forming, disease-producing in man.
Organism E—Rod-shaped, motile, non-spore-forming, produces rot in carrots.

Which of the above organisms would probably require the most intense heating to kill it by sterilization?

A. Organism A. **B.** Organism B. **C.** Organism C.
D. Organism D. **E.** Organism E.

30. *Conservation of Natural Resources*

CONSERVATION OF NATURAL RESOURCES

1. (1.10) Throughout Oklahoma, one of the major problems in providing "good" water for a community is

A. turbidity. **B.** pH. **C.** industrial wastes.
D. deep wells. **E.** irrigation.

True or False.

2. (1.10) Wildlife is not considered to be a renewable natural resource.

True or False.

3. (1.10) Increasing demands of cities are lowering the ground water tables underneath and in surrounding areas.

True or False.

4. (1.10) In meeting increasing demands for more water to be used for irrigation purposes, a wise policy would be to increase the number of wells and pumps.

True or False.

5. (1.10) Utilization of all grassland for crop farming would be a sound conservation measure.

True or False.

6. (1.10) The United States uses from 4 to 10 times as much water per capita as Europe.

7. (1.10) Which of the following is the best place to send for movies on conservation?

A. Your local superintendent of schools.
B. The extension service of your state university.
C. The Department of the Interior in Washington.
D. Walt Disney, Inc., in Hollywood.

8. (1.10) Black or humus soil is produced primarily by the action of

A. microorganisms of decay. **B.** differential erosion.
C. surface and ground water.
D. cultivation and grazing. **E.** none of the above.

9. (1.10) The chief factor in the production of black or humus soils is the action of

A. running water. **B.** differential erosion.
C. bacteria on organic material.
D. cultivation and grazing. **E.** ground water.

10. (1.10) Which factor causes the greatest amount of soil erosion in the U. S. over long periods of time?

A. Sheet erosion. **B.** Severe floods.
C. Wind erosion. **D.** Lowering of soil water table.
E. Glaciation.

11. (1.10) Which element essential to crops is usually most difficult to retain in agricultural soils?

A. Potassium. **B.** Nitrogen. **C.** Phosphorus.
D. Calcium (lime). **E.** Polonium.

Item 12 deleted.

13. (1.20) If you are attempting to conserve soil water, which of the following procedures will be most effective?

A. Cultivate the soil frequently.
B. Plow furrows up and down the slopes to provide drainage.
C. Allow the weeds to grow and form a close cover over the ground.
D. Plant an orchard or walnut grove on the plot of ground.
E. Pack the soil tightly with a steam roller.

14. (1.20) A natural resource that cannot be replaced when once used is

A. water. **B.** lumber. **C.** soil. **D.** natural gas.
E. nitrogen.

15. (1.20) A natural resource that is most essential in determining where industry can be developed is

A. food. **B.** climate. **C.** coal. **D.** oil.
E. water.

16. (1.20) One of the following is considered to be a sound wildlife conservation practice.

A. The destruction of all predatory animals.
B. Burning off a pastureland in the early spring.
C. Allowing no hunting or fishing.
D. Letting weeds and grass, etc., grow in fence corners, gullies, fence rows, etc., throughout the farm.
E. Destruction of all crows and blackbirds.

17. (1.20) Which of the following would be least likely to have an effect upon the ecological distribution of plants?

A. Soil temperature.
B. Penetration of light into the soil.
C. Chemical composition of the soil.
D. Porosity of the soil.
E. Level at which water stands in the soil.

18. (1.20) Which one of the following does the most damage to renewable natural resources?

A. Flood. **B.** Disease. **C.** Man. **D.** Fires.
E. Wind.

19. (1.20) Of the following the one which is *not* usually a soil conservation measure is

A. strip cropping. **B.** contour farming.
C. reservoir construction. **D.** terracing slopes.
E. strip mining.

20. (1.20) Soil is composed of

A. dead organic matter. **B.** mineral particles.
C. microorganisms. **D.** none of these. **E.** all of these.

For items 21 - 32 mark space

A. If the item is true for forests.
B. If the item is true for wild game.
C. If the item is true for farm lands.
D. If the item is true for more than one of the above.
E. If the item is true of none of the above.

21. (1.20) Buffer areas are a means of conserving this domain.

22. (1.20) Disturbance of "the balance of nature" in this domain may have serious consequence.

23. (1.20) Strip cropping and terracing have been used to rehabilitate some misused portions of this domain.

24. (1.20) Unwise use of this domain has resulted in a greater number of floods.

25. (1.20) This domain has never showed a decrease in productive capacity.

26. (1.20) Parasites may affect the productivity of this domain.

27. (1.20) The application of the laws of genetics to the organisms in this domain increase productivity more than in any other area.

28. (1.20) Education has been effective in increasing the economic value of this domain.

29. (1.20) Saprophytes are important in this domain.

30. (1.20) This domain is an outstanding example of ruthless exploitation, abandonment, and movement to other areas for new exploitation by unscrupulous operators.

31. (1.20) The unwise use of this domain has caused great economic losses.

32. (1.20) An adequate conservation program for this domain should include protection against fire, fungus and insect control, government controlled operations, new planting, balance in nature.

33. (1.20) Which definition of conservation is *least* appropriate?

A. Sustained yield production.
B. Preservation or restoration of primeval nature.
C. The best use of our resources for the most people in the long run.
D. Resource management.

34. (1.20) If you're engaged in regional planning in hilly land where the foremost need was flood control, you would recommend

A. reforestation of slopes.
B. power dams and reservoirs in the valley.
C. permanent pastures on slopes.
D. strip cropping of slopes.

35. (1.20) Which of the following is *least* helpful in soil conservation?

A. Contour plowing. **B.** Weed eradication.
C. Spreading of commercial fertilizer.
D. Crop rotation.

36. (1.20) In support of conservation education before your local school board, you would stress most of all its relation to

A. preservation of wilderness areas.
B. our pioneer heritage.
C. wild flower and song bird protection.
D. our standard of living.

37. (1.20) Which of the following methods is most effective in preventing floods?

A. Building dams.
B. Maintaining the vegetation of the watershed.
C. Deepening stream channels and providing levees, spillways and diversion canals.
D. Removing snow from the watershed.

38. (1.20) Plowing up new ground in the Dust Bowl area was disastrous because of

A. the poor agricultural training of the farmers.
B. the tenant farm system.
C. insufficient yearly rainfall.
D. lack of organic matter in the soil.
E. the practice of deep plowing.

39. (1.20) Soil erosion does not occur in a forest for several reasons, one of which is that

A. trees grow on the contour.
B. the foliage absorbs the rainfall.
C. the leaf mold absorbs the rainfall.
D. the rocks are closer to the surface.

40. (1.20) A problem of great importance to our welfare which still awaits scientific attention is that of

A. reforestation. **B.** the control of soil erosion.
C. the purification of municipal water supplies.
D. the recovery of sewage water and wastes.

41. (1.20) Which of the following practices would be the *least* effective soil conservation measure?

A. Planting sloping land in sections that run perpendicular to the direction of wash.
B. Changing from year to year the type of crop that is grown in a field.
C. Plowing and planting in a direction perpendicular to the slope.
D. Converting marginal land into pastures for cattle.
E. Building terraces at right angles to the slope.

42. (1.20) Most of the problems of wild life conservation in the United States can be traced to

A. inadequate food and cover.
B. too many carnivores.
C. too low a birth rate among desirable wild life.
D. too great hunting pressure. **E.** disease.

43. (1.30) The biological principle that can *best* serve as the basis for a public conservation program would be

A. extinction of species follows destruction of their natural habitat.
B. the number of individuals of a species in a population depends upon the number of young produced that attain maturity and have an opportunity to produce their kind.
C. man is not a natural member of most ecological habitats.
D. our natural plant and animal resources are to be considered a public crop to be planted, cultivated and harvested in accord with modern agricultural practice.
E. each generation is responsible for attempting to repair the consequences from having upset the natural balance of organisms in communities.

Items 44 - 51 are based upon the following discussion of soil erosion. Each sentence is numbered, and the items on the next page refer back to specific sentences in the reading passage.

1) As the surface of a sloping soil is gradually eroded away, the upper part of the horizon beneath is gradually changed and incorporated into its lower part. 2) In turn, the upper part of the third horizon is changed and becomes the lower part of the second, until finally new, fresh minerals from the rock beneath are incorporated into the lower part of the lowest horizon. 3) Other soils, instead of having fresh minerals added to the bottom, have them added to the top. 4) Silty coverings are left by the overflow of rivers onto the surface of young alluvial soils like those along the Nile. 5) Probably a third of the people of the world get their food supply from alluvial soils. 6) On

many soils dust and volcanic ejecta fall. 7) As air enters and leaves the soil with wetting and drying, some gases are expelled and others absorbed. 8) Rain brings soluble materials from the air, and percolating water leaches out materials. 9) These actions change the soil materials because the various minerals and other compounds vary in solubility and rates of decomposition.

10) About 1926, a few popular articles on soil erosion attracted public attention. 11) The success of these stimulated others. 12) Soon many articles and books were appearing on the dramatic story of catastrophic erosion. 13) Pictures of great gullies were printed along with statements of the cost of erosion to the United States. 14) Estimates were made of the plant nutrients —phosphorus, potassium, calcium, and the like—washed as soil into streams, lakes, and oceans. 15) Assuming that all these are available to plants, assuming the value for the chemical nutrients equal to that of commercial fertilizer, assuming that all sediment is useless, and assuming that the material exposed by erosion is all sterile—cost figures become truly astronomical. 16) Greater recognition of biological factors in soil management has been long overdue. 17) But the advocates of the organic-matter doctrine go very far. 18) They insist that organic matter is everything, or nearly so; that the usual chemical fertilizers are downright poisonous to soils; that the liberal use of compost gives special qualities to plants that will keep them free of insects and diseases; and that animals, or even people, will be ever so much more healthy by eating plants grown "the organic way."

19) The principal point in the process is the reduction of the ratio of carbon to nitrogen. 20) In normal soil, this ratio is in the neighborhood of 10 or 12. 21) In the fresh organic matter, it is much higher—30 or 40, or even more. 22) If the fresh material is added to the soil directly, microorganisms will increase enormously in the soil, using the energy-giving carbohydrates. 23) They require nitrogen for their bodies and will compete with plants for the available supply. 24) Of course, when the carbohydrates are used up, the numbers of microorganisms will again return to normal and the nitrogen in their bodies will be available to plants. 25) But by composting in advance, this initial period takes place outside the soil, and the resulting compost contains nitrogen available to plants. 26) Further, decomposition in the soil of fresh organic matter requires more moisture than is sometimes available.

Evaluate items 44 - 50 according to the following Key:

KEY

A. In agreement with the general ideas expressed in the designated sentences.
B. In disagreement with the general ideas expressed in the designated sentences.
C. Unrelated to or neither agrees nor disagrees with the general ideas expressed in the designated sentences.

44. (2.20) Sentences 1 through 5. Erosion is a totally destructive phase of the soil-building process.

45. (2.20) Sentences 1 through 5. Erosion renders plant nutrients unavailable to the agricultural industry.

46. (2.20) Sentences 6 through 9. The rate at which rain falls on the soil determines the rate at which it loses its productivity.

47. (2.20) Sentences 10 through 15. Many biological principles are interwoven in the problem of soil conservation.

48. (2.20) Sentences 16 through 26. The greater the number of microorganisms living in the soil, the greater the amount of nitrogen immediately available to plants.

49. (2.20) Sentences 16 through 26. Many leguminous plants harbor bacteria in their roots that can make atmospheric nitrogen available to soils.

50. (2.20) Sentences 16 through 26. The microorganisms most closely associated with soil fertility are those which feed upon dead plants.

51. (2.20) In sentence 15 the author exemplifies the phase of scientific problem solving identified as

A. analysis of the problem.
B. establishment of hypotheses.
C. gathering data.   **D.** analysis of data.
E. subjecting the hypotheses to experimental trial.

31. *Unclassified as to Subject Matter*

UNCLASSIFIED AS TO SUBJECT MATTER

Items 1 - 10.

KEY

A. Amphibia. B. Angiospermae. C. Bryophyta.
D. Class. E. Dicotyledoneae. F. Family.
G. Genus. H. Gymnospermae. I. Kingdom.
J. Monocotyledoneæ. K. Order. L. Phylum.
M. Pisces. N. Pteridophyta. O. Species.

1. (1.10) Categories employed in naming an organism according to the binomial system.

2. (1.10) The highest category under which organisms are grouped.

3. (1.10) Mammalia is an example of what category?

4. (1.10) Platyhelminthes (flat worms) exemplify what category?

5. (1.10) Diptera (flies), Lepidoptera (butterflies), Coleoptera (beetles), all exemplify what category?

6. (1.10) Taxonomic group to which pine trees are assigned.

7. (1.10) Taxonomic group to which fish are assigned.

8. (1.10) Taxonomic group to which ferns are assigned.

9. (1.10) Taxonomic group to which sunflowers are assigned.

10. (1.10) Taxonomic group to which grasses are assigned.

For items 11 - 20 assume that you are familiar with all of the biological facts and information currently available and evaluate the following statements according to the key.

KEY

A. 100% sure that the statement is true.
B. 100% sure that the statement is false.
C. The statement is very probably true.
D. The statement is very probably false.
E. It is impossible to indicate any marked degree of truth or falsity.

11. (1.10) All present forms of life have evolved from a primordial form.

12. (1.10) All races of the human species are equally susceptible to all diseases.

13. (1.10) Just as the mammals replaced reptiles as the dominant life on the earth so will insects eventually displace the mammals.

14. (1.10) Heredity rather than the environment in which they will live, will play the greater part in determining the characteristics of the next generation of living organisms.

15. (1.10) Sterilization laws, if enforced, would reduce crime.

16. (1.10) There has been a recurrent cycle of rising and sinking continents in the history of the earth.

17. (1.10) There never will be a single drug or chemical that will entirely wipe out insect life on the earth.

18. (1.10) No form of life can exist without water.

19. (1.10) There is no organism that does not have to compete with some other organism at some time in its life history.

20. (1.10) Parasitism will ultimately lead to the extinction of the host organism.

Items 21 - 28.

KEY

A. Acute poisoning. B. Alcohol. C. Barbituates.
D. Caffeine. E. Chronic poisoning. F. Cocaine.
G. Dysphoria. H. Euphoria. I. Hangover.
J. Hypnotics. K. Marihuana. L. Morphine.
M. Stimulants. N. Strychnine. O. Tobacco.

21. (1.10) A habit-forming derivative of opium frequently used in the alleviation of pain.

22. (1.10) Habit-forming drugs classed as narcotics.

23. (1.10) Alcoholism.

24. (1.10) Habit-forming derivatives of barbituric acid.

25. (1.10) Cigarettes and coffee.

26. (1.10) Absence of a sense of well being.

27. (1.10) Dangerous narcotic used largely in the form of cigarettes.

28. (1.10) Dangerous group of habit-forming drugs, the sale of which is restricted in Europe but uncontrolled on a nation-wide scale in the U. S.

Items 29 - 38.

KEY

A. Audubon. B. Cuvier. C. Darwin, Charles.
D. De Vries. E. Galen. F. Harvey.
G. Hippocrates. H. Jenner. I. Lamarck.
J. Linnaeus. K. Mendel. L. Pasteur.
M. Sears, P. B. N. Koch. O. Weismann.

29. (1.10) The man who outlined 4 postulates for proving the cause of a specific disease.

30. (1.10) The "father" of medicine.

31. (1.10) The man who proved by logic that the blood in our bodies circulates.

32. (1.10) An authority on anatomy for 1200 years.

33. (1.10) The author of the "mutation" theory.

34. (1.10) The "father" of comparative anatomy.

35. (1.10) The founder of our present system of taxonomy.

36. (1.10) The author of "use and disuse of parts" as an explanation of evolution.

37. The author of "Deserts on the March."
(1.10)

38. The man who discovered that bacteria are killed by heating.
(1.10)

Items 39 - 49.

KEY

A. Acute. **B.** Allergy. **C.** Antibiotic.
D. Chronic. **E.** Chiropractor. **F.** Congenital.
G. Contagious. **H.** Diabetic. **I.** Immune.
J. Neurologist. **K.** Obstetrician. **L.** Osteopath.
M. Pathogen. **N.** Pediatrician. **O.** Optometrist.

39. A disease due to sensitivity to a foreign protein is classed as a(n)
(1.10)

40. Streptomycin is a(n)
(1.10)

41. A disease which one is "born with."
(1.10)

42. A medical practitioner who treats disease with drugs, surgery, and manipulation of the bones and muscles.
(1.10)

43. A disease spread by personal contact.
(1.10)

44. A physician who specializes in the care of expectant mothers and childbirth.
(1.10)

45. A disease which waxes and wanes, i.e., comes and goes.
(1.10)

46. A person who specializes in the fitting of glasses.
(1.10)

47. A medical practitioner who treats body ailments primarily by the manipulation of the skeleton.
(1.10)

48. A person who is unable to utilize sugar.
(1.10)

49. A disease-causing organism.
(1.10)

50. Red eye is dominant to sepia; gray body is dominant to ebony. *No sex-linkage.* The offspring of a certain mating included 18 red gray, 6 red ebony, 18 sepia gray and 6 sepia ebony. Circle correct answers.
(1.20)

One parent was: sepia, red; homozygous, heterozygous ebony, gray; homozygous, heterozygous.

The other parent was: sepia, red; homozygous, heterozygous ebony, gray; homozygous, heterozygous.

51. Miniature wing is recessive to long, *sex-linked.* There were some miniature and some long male offspring from a certain mating but all the female offspring were long. Circle correct answers.
(1.20)

The female parent was: miniature, long; heterozygous, homozygous.

The male parent was: miniature, long.

Items 52 - 94. The following paired statements refer to structures, functions, or factors which are to be compared in a quantitative sense. Blacken answer space:

A if the thing on the left is greater than the thing on the right.
B if the thing on the left is less than the thing on the right.
C if the thing on the left is approximately the same as the thing on the right.

52. (1.20)	The geological age of the oldest *pterioophytes* is	**A.** greater than **B.** less than **C.** same as	the geological age of the oldest *angiosperms.*
53. (1.20)	The total energy *used in the proccess of respiration* by a green plant during the average summer day is	**A.** greater than **B.** less than **C.** same as	the total energy *fixed by photosynthesis* of the same plant during the same day.
54. (1.20)	The number of chromosomes in the *egg* of a plant is	**A.** greater than **B.** less than **C.** same as	the number of chromosomes in the *sperm* of a plant.
55. (1.20)	The age of the oldest individual *tree* is	**A.** greater than **B.** less than **C.** same as	the age of the oldest individual living *mammal.*
56. (1.20)	The number of chromosomes per cell in typical dicot *endosperm* tissue is	**A.** greater than **B.** less than **C.** same as	the number of chromosomes per cell in typical dicot *embryo* tissue.
57. (1.20)	The number of diseases caused by *saprophytes* is	**A.** greater than **B.** less than **C.** same as	the number of diseases caused by *parasites.*
58. (1.20)	The energy stored in a gram of *starch* in seeds such as corn is	**A.** greater than **B.** less than **C.** same as	the energy stored in a gram of *oil* in seeds such as peanuts.
59. (1.20)	The number of chromosomes in nucleus *before* mitosis is	**A.** greater than **B.** less than **C.** same as	the number of chromosomes in each *daughter nucleus after* mitosis.
60. (1.20)	The closeness of relationship of *mosses to liverworts* is	**A.** greater than **B.** less than **C.** same as	the closeness of relationship of *mosses to ferns.*
61. (1.20)	The height of a seedling grown in *darkness* is	**A.** greater than **B.** less than **C.** same as	the height of a seedling grown in *light.*
61. (1.20)	The temperature of the usual habitat of most *brown* algae is	**A.** greater than **B.** less than **C.** same as	the temperature of the usual habitat of most red algae.
62. (1.20)	The surface area of the *"above ground"* portion of most seed plants is	**A.** greater than **B.** less than **C.** same as	the surface area of the *"below ground"* portions of most seed plants.
63. (1.20)	The turgor pressure of cells in carrot sticks after ten minutes of immersion in *pure water* is	**A.** greater than **B.** less than **C.** same as	the turgor pressure in the same carrot stick cells after ten minutes of immersion in *10% salt solution.*

64. (1.20)	The number of different kinds of offspring from the cross *CCss* x *ccSS* is	**A.** greater than **B.** less than **C.** same as	the number of different kinds of offspring from the cross *Rr* x *Rr*.
65. (1.20)	The number of phenotypes in the F_1 of a monohybrid cross showing *complete dominance* is	**A.** greater than **B.** less than **C.** same as	the number of different kinds of F_1 of a monohybrid cross with *dominance lacking*.
66. (1.20)	The chance of any two brown-eyed parents having a blue-eyed child is	**A.** greater than **B.** less than **C.** same as	the chance of any two blue-eyed parents having a brown-eyed child.
67. (1.20)	The number of vessels in an *elm* tree is	**A.** greater than **B.** less than **C.** same as	the number of vessels in a *pine* tree of the same height as the elm.
68. (1.20)	The probable value of *legume* crop (alfalfa) in supplying nitrogen to the soil is	**A.** greater than **B.** less than **C.** same as	the probable value of a *grass* crop (oats) in supplying nitrogen to the soil.
69. (1.20)	The importance of fungi in nitrogen fixation is	**A.** greater than **B.** less than **C.** same as	the importance of *bacteria* in nitrogen fixation.
70. (1.20)	Concentration of urea in blood *plasma* is	**A.** greater than **B.** less than **C.** same as	concentration of urea in the *fluid filtered through the glomerus* of the kidney.
71. (1.20)	The degree to which components of *bile* act as enzymes in digestion is	**A.** greater than **B.** less than **C.** same as	the degree to which components of *pancreatic juice* act as enzymes in digestion.
72. (1.20)	Extent to which the human embryo depends upon food *initially* in the egg, 3 days after fertilization is	**A.** greater than **B.** less than **C.** same as	extent to which the human embryo depends upon food *obtained from circulation blood of the mother,* 3 days after fertilization.
73. (1.20)	The length of time that the mature *egg cell* remains viable in man, after leaving the ovary is	**A.** greater than **B.** less than **C.** same as	the length of time that the mature *sperm cell* remains viable in man, after leaving the testis.
74. (1.20)	The fraction of *Hydra* eggs which develop to adulthood is	**A.** greater than **B.** less than **C.** same as	the fraction of *beef tapeworm* eggs which develops to adulthood.
75. (1.20)	The average size of food particles taken into a *tapeworm* is	**A.** greater than **B.** less than **C.** same as	the average size of food particles taken into a *free-living flatworm.*
76. (1.20)	Fraction in all living protoplasm which is maintained by *non-parasitic* activities is	**A.** greater than **B.** less than **C.** same as	fraction of all living protoplasm which is maintained by *parasitic* activities.
77. (1.20)	Closeness of relationship between starfishes and *cartilaginous fishes* is	**A.** greater than **B.** less than **C.** same as	closeness of relationship between starfishes and *crustacean shellfishes.*
78. (1.20)	The probable age of the oldest *vertebrate* fossil is	**A.** greater than **B.** less than **C.** same as	the probable age of the oldest *invertebrate* fossil.
79. (1.20)	Percentage of weight increase, on the average, in the 6 months *following* birth, in man is	**A.** greater than **B.** less than **C.** same as	percentage of weight increase on the average, in the 6 months *preceding* birth in man.
80. (1.20)	The change in body temperature of a *bird* moved from a cool room to the hot summer sun is	**A.** greater than **B.** less than **C.** same as	the change in body temperature of an *alligator* moved from a cool room to a cage exposed to the hot summer sun.
81. (1.20)	Volume of blood to be found in the digestive organs of a man *at rest* immediately after a normal sized meal is	**A.** greater than **B.** less than **C.** same as	volume of blood to be found in the digestive organs of a man *engaged in strenuous* work immediately after a normal-sized meal.
82. (1.20)	Percentage of blood which is pumped by the heart, per minute, which goes through the lungs of the human embryo *one month before birth* is	**A.** greater than **B.** less than **C.** same as	percentage of blood which is pumped by the heart, per minute, which goes through the lungs of the human infant *one month after birth.*
83. (1.20)	The amount of iron which is lost from the body as a result of the loss of 100 million red blood cells *by a hemorrhage* is	**A.** greater than **B.** less than **C.** same as	the amount of iron which is lost by the body through the *normal mode of destruction* of 100 million red blood cells.

84. (1.20)	The closeness of the relationship between *centipedes* and *insects* is	**A.** greater than **B.** less than **C.** same as	the closeness of the relationship between *centipedes* and *earthworms.*
85. (1.20)	The likelihood of a *hermit's* possessing a strong resistance to many infectious diseases is	**A.** greater than **B.** less than **C.** same as	the likelihood of a *street-car conductor's* possessing a strong resistance to the same infectious diseases.
86. (1.20)	The average concentration of carbon dioxide in the *body tissues* is	**A.** greater than **B.** less than **C.** same as	average concentration of carbon dioxide in the *alveoli* of the lungs.
87. (1.20)	The average oxygen concentration in the *arteries of the muscles of facial expression* under average conditions is	**A.** greater than **B.** less than **C.** same as	the average oxygen concentration in the *veins of the muscles of facial expression,* at the same time.
88. (1.20)	The fraction of the cells of a typical *seed plant* which carry on photosynthesis	A. greater than B. less than C. same as	the fraction of the cells of typical *green alga* which carry on photosynthesis.
89. (1.20)	Extent to which blood flow during diastole is due directly to squeezing of the blood by the *ventricle* is	A. greater than B. less than C. same as	extent to which blood flow during diastole is due directly to squeezing of the blood by the large *arteries.*
90. (1.20)	The strength of contraction of a single muscle fiber produced by a stimulus whose strength is barely sufficient (i.e., *minimal*) to procontraction is	A. greater than B. less than C. same as	the strength of contraction of the same muscle fiber produced by a stimulus of *twice the minimal intensity.*
91. (1.20)	The work required to pump 1000 cc. of blood through a normal human *arteriole* is	A. greater than B. less than C. same as	the work required to pump 1000 cc. of blood through a normal human *aorta.*
92. (1.20)	The number of annual rings at a *point half-way up the trunk* of an old tree is	A. greater than B. less than C. same as	the number of annual rings at the *base of the trunk* of the same tree.
93. (1.20)	The maximum size of food particles that can be eaten by a *sponge* is	**A.** greater than **B.** less than **C.** same as	the maximum size of food particle that can be eaten by a *coelenterate.*
94. (1.20)	The average volume of blood and lymph flowing *to* the digestive tract, per day is	**A.** greater than **B.** less than **C.** same as	the average volume of blood and lymph flowing *away from* the digestive tract per day.

Items 95 - 107.

✓ Consider each pair of quantities or factors expressed below as if they were a sample of a large and uniform series. Assume that only factors or quantities A and B do change, and that all other factors or quantities remain constant. Then, blacken answer space,

A if B increases as A increases (that is, positive correlation).
B if B decreases as A increases (that is, negative correlation).
C if B does not change as A increases (that is, no correlation).

95. A. Energy of a stimulus applied to a sensory nerve ending.
(1.20) B. Energy of a single nerve impulse started by the stimulus.

96. A. Concentration of parathyroid hormone in the blood (within 20% of normal). ✓
(1.20) B. Metabolic rate.

97. A. Size of human embryo.
(1.20) B. Percentage of cells which are undergoing division.

98. A. Percentage of the diet which is made of protein.
(1.20) B. Rate of urea excretion.

99. A. Quantity of any single non-essential amino acid present as a part of an adequate daily diet of a growing child.
(1.20) B. Rate of growth.

100. A. Concentration of thyroid hormone in the blood.
(1.20) B. Metabolic rate.

101. A. Concentration of follicle-stimulating hormone (FSH) in the blood.
(1.20) B. Thickness of the internal lining of the uterus.

102. A. The concentration of CO_2 in the air within 50% of normal.
(1.20) B. The rate of photosynthesis.

103. A. The relative humidity of air.
(1.20) B. The rate of transpiration.

104. A. The amount of water moving upward in a stem.
(1.20) B. The amount of food translocated downward in a stem.

105. A. The amount of starch in a cell of a potato tuber.
(1.20) B. The osmotic pressure of the same cell.

106. A. The average turgor pressure of guard cells in a leaf.
(1.20) B. The average size of stomata in the same leaf.

107. A. The concentration of auxin near the apex of a stem within 50% of normal.
(1.20) B. The rate of elongation of the same stem.

For items 108 - 117 mark space

- **A** if the first-named structure or substance is included within or constitutes a part of the second.
- **B** if the second-named structure or substance is included within or constitutes a part of the first.
- **C** if neither of the two structures or substances named is included within or constitutes a part of the other one.

108. Iron.
(1.20) Hemoglobin.

109. Human red corpuscle.
(1.20) Organized nucleus.

110. Synapse.
(1.20) Reflex arc.

111. Cochlea.
(1.20) Sensory endings of auditory nerve.

112. Ovary.
(1.20) Graafian follicle.

113. Vitreous humor.
(1.20) Semi-circular canals.

114. Abdominal cavity.
(1.20) Spleen.

115. Cell nucleus.
(1.20) Chromosome.

116. Hydra.
(1.20) Protozoa.

117. Gene.
(1.20) Chromosome.

For items 118 - 130 use the following key:

- A. Statement is *true;* reason *supports* it.
- B. Statement is *true;* reason *does not support* it.
- C. Statement is *false;* reason *supports the contrary.*
- D. Statement is *false;* reason is *false.*

118. (1.20) Except when an individual is afflicted with an incurable disease, there is no scientific basis on which to predict his probable length of life.

Reason: Predisposition to longevity is conditioned solely by the environment.

119. (1.20) Generally speaking, if mutation has not occurred, a man aged 60 when his last child is born is capable of passing on to his child the same kinds of hereditary factors as were transmitted to his first child born when he was 22 years old.

Reason: Germ cells are unaffected by changes in the body cells occurring with advancing intellectual development and age.

120. (1.20) While the embryo is developing, whole blood from the mother's circulatory system filters into the unborn child's circulatory system.

Reason: The placenta is an organ of nutrition and excretion through which osmotic exchange takes place.

121. (1.20) There are more female stillbirths than male.

Reason: The female is the weaker sex.

122. (1.20) Every sperm head contains a tiny embryonic being.

Reason: This was first announced by Circa in the year 1700 A.D. when he named this phenomenon the "homunculus."

123. (1.20) The sex of a child is fixed at the time when fusion between sperm cell and egg occurs and is thereafter unalterable.

Reason: Sex in man is determined by the pH (acidity or alkalinity) of the gametes.

124. (1.20) An illegitimate child cannot be genetically equal to a child of legitimate birth.

Reason: Only genetically inferior individuals have illegitimate children.

125. (1.20) Genetically, a child is the result of what its parents were at the time the child was conceived.

Reason: Each organ or part of a person's body contributes something, called a gemmule, to the sperm or egg, and all the characteristics of both parents will be transmitted to the child by a process of blending which goes on during development.

126. (1.20) The principle "Survival of the Fittest" operates more rigorously in the human race during the 20th century A.D. than it did during the 20th century B.C.

Reason: The law of the jungle has been superseded by modern medical science and ethics.

127. (1.20) The child of an alcoholic father will inevitably become an alcoholic.

Reason: Alcoholism modifies the genes, resulting in a predisposition to alcoholism.

128. (1.20) A harrowing nervous experience by the mother may affect her unborn child and cause it later to develop an unstable nervous temperament.

Reason: A psychological bond exists through their common nervous system between the mother and her unborn child.

129. (1.20) In the United States the incidence of hookworm infestation is highest in the regions where intelligence is lowest.

Reason: Hookworm infestation impairs mentality.

130. (1.20) Gregor Mendel, the "Father of Modern Genetics," twice failed an important examination in botany at the University of Vienna.

Reason: He had been largely self-taught and his academic knowledge was deficient.

For items 131 - 145 mark space

KEY

- **A** if increase in the first is accompanied by increase in the second, or if decrease in the first is accompanied by decrease in the second.
- **B** if increase in the first is accompanied by decrease in the second, or if decrease in the first is accompanied by increase in the second.
- **C** if the second remains constant, or approximately constant, when the first increases or decreases.

131. (1.20)
1. Oxygen concentration of the atmosphere.
2. Number of red corpuscles per cubic millimeter of blood of a person breathing that atmosphere over a long period of time.

132. (1.20)
1. Carbon dioxide concentration in the blood.
2. Rate of breathing.

133. (1.20)
1. Thyroxin secretion in an adult.
2. Body weight in that adult.

134. (1.20)
1. Number of inbred generations of a given population.
2. Heterozygosity of that population.

135. (1.20)
1. Amount of carbohydrate in the diet of an individual.
2. Blood sugar concentration in that individual's blood.

136. (1.20)
1. Insulin secretion in an individual.
2. Sugar in that individual's urine.

137. (1.20)
1. Ratio of cerebrum weight to body weight in a species.
2. Length of the period of development in that species.

138. (1.20)
1. Amount of adrenalin secreted.
2. Amount of sugar in the blood.

139. (1.20)
1. Incidence of communicable diseases.
2. Death rate from degenerative diseases.

140. (1.20)
1. Number of mutations in a given species.
2. Potential rate of evolutionary change of that species.

141. (1.20)
1. Size of molecules in a solution.
2. Ease of diffusibility through a membrane.

142. (1.20)
1. Amount of glucose produced in photosynthesis.
2. Amount of oxygen liberated during photosynthesis.

143. (1.20)
1. Intelligence Quotient.
2. Creative ability.

144. (1.20)
1. Innate intelligence.
2. Potential educability.

145. (1.20)
1. Number of genes.
2. Number of heritable traits.

146. (3.00) The theoretical ratio among the offspring of a certain mating was: ¼ blood group A, ¼ group B, ½ group AB.

The parents were ( ) O; ( ) het. A; ( ) hom. A.
Two check marks ( ) het. B; ( ) hom. B; ( ) AB.

147. (3.00) Black body is recessive to gray, *not sex-linked;* vermilion eye is recessive to red, *sex-linked.* A gray vermilion male (whose father was black red) was mated to a gray red female (whose mother was black vermilion). Their offspring were: (Fill in the parentheses with fractions).

( ) black vermilion males.
( ) black red males.
( ) gray vermilion males.
( ) gray red males.
( ) black vermilion females.
( ) black red females.
( ) gray vermilion females.
( ) gray red females.

148. (3.00) Black is recessive to gray body, short wing is recessive to long, *no sex-linkage.* The offspring of a certain mating included 15 gray long, 15 black long, 5 black short and 5 gray short. Encircle correct answers.

One parent was:
black, gray; heterozygous, homozygous.
short, long; heterozygous, homozygous.

The other parent was:
black, gray; heterozygous, homozygous.
short, long; heterozygous, homozygous.

149. (3.00) Red eye is dominant to vermilion, *sex-linked.* There were some red and some vermilion males among the offspring of a certain mating, but all the female offspring were red. Encircle correct answers.

The female parent was: vermilion, red homozygous, heterozygous.

The male parent was: vermilion, red.

150. (3.00) Black body color is recessive to gray. A certain male was mated to a homozygous gray female. Half the offspring were homozygous gray and half were heterozygous.

The male was: black, gray; heterozygous, homozygous. (Encircle correct answer.)

The same male was then mated to one of his heterozygous daughters. Their offspring were: (Fill in the parentheses with fractions.)

( ) homozygous black. ( ) heterozygous gray.
( ) homozygous gray.

151. (3.00) An individual belonging to blood group A (one of whose parents was in a group O) was mated to an individual in group AB (one of whose parents was in group B). What would be the theoretical ratio among the offspring of this mating? (Fill in the parentheses with fractions.)

( ) O; ( ) het. A; ( ) hom. A;
( ) het. B; ( ) hom. B; ( ) AB.

152. (3.00) Long wing is dominant to short wing, *not sex-linked;* gray body is dominant to yellow body, *sex-linked.* A short winged, gray male was mated to a yellow long female (one of whose parents had short wings). Their offspring were: (Fill in the parentheses with fractions.)

( ) short yellow males.
( ) short gray males.
( ) long yellow males.
( ) long gray males.
( ) short yellow females.
( ) short gray females.
( ) long yellow females.
( ) long gray females.

153. (3.00) Long dominant to short wing; red dominant to brown eye, *no sex-linkage.* The offspring of a certain mating included 45 long red, 15 long brown, 15 short red and 5 short brown. Encircle correct answers.

One parent was:
long, short; heterozygous, homozygous.
red, brown; heterozygous, homozygous.

The other parent was:
long, short; heterozygous, homozygous.
red, brown; heterozygous, homozygous.

154. (3.00) Yellow body is recessive to gray body, *sex-linked.* In addition to other offspring of a certain mating there were some yellow females and some gray males. (Encircle the correct answers.)

The male parent was: yellow, gray.
The female parent was: yellow, gray; heterozygous, homozygous.

155. (3.00) Long wing is dominant to short wing. A certain male was mated to a short female. All the offspring were long. The male was: long, short; heterozygous, homozygous. (Encircle correct answers.)

The same male was then mated to one of his daughters. Their offspring were: (Fill in the parentheses with fractions.)

( ) homozygous long. ( ) heterozygous long.
( ) homozygous short.

156. (3.00) The theoretical ratio among the offspring of a certain mating was: ½ blood group A; ¼ group B, and ¼ group AB.

The parents were: ( ) O; ( ) het. A; ( ) hom. A;
Two check marks. ( ) het. B; ( ) hom. B; ( ) AB.

157. Short wing is recessive to long wing, *not sex-linked;* yellow is recessive to gray body, *sex-linked.* A yellow long male (one of whose parents was short) was mated to a gray short female (one of whose parents was yellow). Fill in parentheses with fractions. Their offsprings were
(3.00)

( ) short yellow males. ( ) short yellow females.
( ) short gray males. ( ) short gray females.
( ) long yellow males. ( ) long yellow females.
( ) long gray males. ( ) long gray females.

158. Short wing is recessive to long; brown eye is recessive to red; *no sex-linkage.* The offspring of a certain mating included 24 long red, 24 long brown, 8 short red and 8 short brown. Encircle correct answers.
(3.00)

One parent was:
long, short; heterozygous, homozygous.
red, brown; heterozygous, homozygous.

The other parent was:
long, short; heterozygous, homozygous.
red, brown; heterozygous, homozygous.

159. Gray body is dominant to yellow, *sex-linked.* There were some yellow and some gray male offspring from a certain mating but all the female offspring were gray. Encircle correct answers.
(3.00)

The female parent was: gray, yellow; homozygous, heterozygous.

The male parent was: gray, yellow.

160. Short wing is recessive to long wing. A certain male was mated to a long female. Half the offspring were long and half were short.
(3.00)

The male was: short, long; homozygous, heterozygous. (Encircle correct answers.)

The same male was mated to one of his heterozygous daughters. Their offspring were: (Fill in the parentheses with fractions.)

( ) homozygous long. ( ) heterozygous long.
( ) homozygous short.

161. An individual belonging to blood group B (one of whose parents was in group O) was mated to an individual belonging to group AB (one of whose parents was in group A). What would be the theoretical ratio among the offspring of this mating? Fill in the parentheses with fractions.
(3.00)

( ) O; ( ) het. A; ( ) hom. A;
( ) het. B; ( ) hom. B; ( ) AB.

162. Red is dominant to sepia eye, *not sex-linked;* long is dominant to miniature wing, *sex-linked.* A long red male (whose father was sepia) was mated to a miniature red female (whose father was sepia and whose mother was long).
(3.00)

Their offspring were: (Fill in the parentheses with fractions.)

( ) red long males. ( ) red long females.
( ) red miniature males. ( ) red miniature females.
( ) sepia long males. ( ) sepia long females.
( ) sepia miniature males. ( ) sepia miniature females.

For items 163 - 171 check the paired events according to the following key:

✓ **A.** The second must accompany or be preceded by the first.
B. The second usually but not invariably is accompanied by or is preceded by the first.
C. The first must be preceded by the second.
D. There is no great probability that either is more apt to accompany or precede the other.

163. Oxidation of digested foods or body tissue – Heat to maintain normal body temperature.
(3.00)

164. Bacterial infection – Body temperature above 98.6°F.
(3.00)

165. Bite of an Anopheles mosquito – Typhus fever.
(3.00)

166. Natural selection – Evolution.
(3.00)

167. Stimulation of living nerve ending – Transmission of a nerve impulse.
(3.00)

168. Secretion of hydrochloric acid by gastric glands – The action of rennin and pepsin on protein in the stomach.
(3.00)

169. Passage of a specific blood corpuscle through the kidney – Passage of the same corpuscle through the pulmonary artery.
(3.00)

170. Removal of forests – Greater range of temperature changes.
(3.00)

171. Formation of gametes – Reduction-division.
(3.00)

172. Red eye is dominant to sepia. A certain male was mated to a red female. Half their offsprings were red and half were sepia.
(3.00)

The male was: red, sepia; heterozygous, homozygous. (Encircle correct answers.)

The same male was then mated to one of his heterozygous daughters. Their offsprings were: (Fill in the parentheses with fractions.)

( ) homozygous sepia. ( ) heterozygous red.
( ) homozygous red.

B. Physical Science Content Categories

1. *Nature of Science and Science Methods*

NATURE OF SCIENCE AND SCIENCE METHODS

1. At the present time, the Law of Conservation of Mass is actually
(1.1)

A. a theory. **B.** an hypothesis.
C. a law in itself.
D. a special case of a more general law.
E. none of these.

2. Inductive reasoning is a phase of logic concerned primarily with
(1.1)

A. solving problems by formulas.
B. classification and systematic organization of facts.
C. developing laws from a study of assembled facts.
D. observing natural phenomena.
E. the statement of a theory.

3. One of the baffling features of the advance of science lies in the
(1.1)

A. unpredictable way in which revolutionary ideas have developed.
B. reluctance of famous scientists to accept new ideas or concepts.
C. slow development of new ideas by logical thought.
D. reluctance of professors and scientists to mingle with artisans.
E. reluctance with which new ideas have been applied to everyday events.

Questions 4 - 12 should be answered in accordance with the opinions and point of view expressed by Conant.

4. The significance of Toricelli's experiment for those studying the methods of science lies in the fact that
(1.1)

A. it can be easily and quickly duplicated in any laboratory.
B. it can be readily verified.
C. it is a broad hypothesis or conceptual scheme.
D. it is simple evidence of one consequence of a broad hypothesis or conceptual scheme.
E. it shows the immediate application of a broad hypothesis or conceptual scheme to a pressing problem of the day.

5. One of the reasons why the Phlogiston Hypothesis was accepted for over a hundred years was that
(1.1)

A. scientists of that day were less intelligent than modern scientists.
B. gases were commonly believed to have zero or negative weight.
C. scientists of that day were not really good observers.
D. men were too set in their ways to accept the theory of oxidation.
E. a better theory could not have been formulated until Dalton's Atomic Theory became known.

6. According to Conant, the rebirth of the idea of air as an elastic medium is an example of
(1.1)

A. a concept arising from an experiment.
B. a limited working hypothesis.
C. an experiment giving rise to deduced consequences.
D. a limited working hypothesis arising from a concept.
E. None of these.

7. Conant believes that
(1.1)

A. few if any hypotheses on a grand scale can be directly tested.
B. unlike hypotheses, conceptual schemes can be directly tested.
C. unlike conceptual schemes, most hypotheses on a grand scale can usually be tested directly.
D. hypotheses on a grand scale are tests of conceptual schemes.
E. both hypotheses on a grand scale and conceptual schemes can usually be tested directly.

8. According to Conant, the idea that Galileo used to explain the failure of pumps to raise water more than 34 feet was that
(1.1)

A. nature abhors a vacuum.
B. mechanical defects existed in all pumps.
C. water is incompressible.
D. a water column, like a long wire, breaks under a stress.
E. atmospheric pressure was a causal factor.

9. Select the one condition which contributes *least* toward the development of a conceptual scheme.
(1.1)

A. The time must be ripe for scientific discovery to be effective.
B. Scientific variables must be controlled.
C. A previous accepted conceptual scheme which already explains the phenomena.
D. The adoption of ad hoc (special or for this purpose only) assumptions to support theories.
E. The use of deductive experimentation or tests.

10. Avogadro's hypothesis concerning the relationship between volumes of gases and the number of particles or molecules they contain is now considered a
(1.23)

A. generalization. **B.** conceptual scheme.
C. discarded hypothesis. **D.** law.
E. fruitful hypothesis.

11. The concept of atmospheric pressure
(1.1)

A. was proved by the simple process of deductive reasoning.
B. depended upon the presence of a funiculus.
C. could never have arisen without a knowledge of Guy Lussac's law.
D. led Boyle into a series of fruitful experiments dealing with vacuums.
E. proves that nature abhors a vacuum.

12. Conant states that, "Few if any pioneers have arrived at their important discoveries by a systematic process of logical thought." Instead, he suggests that the responsible factors were most often
(1.1)

A. brilliant flashes of imagination or "hunches."
B. the painstaking efforts of their predecessors.
C. the combining of the efforts of artisans as well as learned men.
D. the often-fumbling efforts of the artisans to solve pressing problems.
E. suggestions or ideas either coming from the past or from their contemporaries.

396A

13. (1.1) In the examination of crystalline table salt (sodium chloride), the chemist determines the presence of sodium and chlorine. His study demonstrates experimentation in the following fields:

A. qualitative chemical analysis.
B. quantitative chemical analysis.
C. organic chemical analysis.
D. physical chemical analysis. **E.** bio-chemistry.

14. (1.1) A theory is

A. used interchangeably with the word "principle."
B. the method of applying some principle to the solution of a problem.
C. a generalization standing midway between a hypothesis and law.
D. a generalization standing midway between a hypothesis and principle.

15. (1.1) Galileo considers his sciences to be "new" in the sense that they

A. take into account the facts of nature.
B. deal with phenomena never before investigated.
C. avoid abstractions and adhere to inductions from observations.
D. involve novel and original uses of mathematical proof.
E. rest upon application of mathematical methods to physical principles heretofore unknown.

16. (1.23) The process in which one systematically observes and builds up piecemeal scientific principles is called

A. deduction. **B.** induction. **C.** intuition.
D. hypothesis.

Items 17 - 24 involve terms used in science. Select from the key the most closely related term for each of the items.

KEY

A. Hypothesis. **B.** Theory. **C.** Natural law.
D. Definition. **E.** None of these.

17. (1.23) Our senses observe and interpret within certain limitations.

18. (1.23) The atom is composed of electrons, protons, and usually neutrons.

19. (1.23) Natural philosophy is concerned with fundamental concepts of time and space, matter and energy, and their relationship with each other.

20. (1.23) $F = \frac{k\ Mm}{d^2}$ or $F = \frac{8.8_2}{hd^2}$

21. (1.23) One of the explanations of the origin of the solar system is known as the planetesimal.

22. (12.3) A conclusion drawn from many particular observations is known as a special type of reasoning.

23. (1.23) Science frequently uses statements agreeing with all observations made so far or a tentative principle which is plausible on the basis of observations.

24. (1.23) In every sample of any compound substance, formed or decomposed, the proportion by weight of the constituent elements is always the same.

25. (1.23) Proust's "Law of Definite Proportions," which states that, "The elements which make up a chemical compound are combined in a definite proportion by weight," is a

A. concept which arose out of abstract thinking.
B. generalization which was developed as a means of integrating many observed facts.
C. hypothesis which stemmed from a concept by means of a chain of reasoning.
D. conceptual scheme which was theorized from a set of proven hypotheses.
E. general unsubstantiated belief becoming accepted as law as a result of the passage of time.

Items 26 and 27 involve terms used in science. Select from the key the most closely related term for each item.

KEY

A. Definition. **B.** Observation. **C.** Theory.
D. Verification of hypothesis. **E.** Natural law.

26. (1.23) The atom consists of a positive nucleus with one or more planetary electrons revolving around it in orbital motion.

27. (1.23) In every sample of any compound substance, formed or decomposed, the proportion by weight of the constituent elements is always the same.

28. (1.23) $F = \frac{KMm}{d^2}$ is an expression of

A. a natural law. **B.** an hypothesis.
C. a theory. **D.** an assumption.

29. (1.23) A statement such as, "The heats of formation between the halogens and carbon were checked and they increase from iodine to fluorine," represents

A. a hypothesis. **B.** a problem.
C. the specification of a problem.
D. data used in the solution of a problem.
E. none of these.

30. (1.23) From the general principle that "to every action there is always an equal reaction" it may be concluded that a rocket ship will travel out in space, moving forward by reaction from the materials ejected. This best illustrates

A. inductive reasoning. **B.** deductive reasoning.
C. testing an hypothesis experimentally.
D. discovering a scientific law.
E. utilization of common sense.

31. (1.23) When one evolves a new explanation of why a certain cause produces a certain effect with the idea of testing the explanation observationally or experimentally, it is *most* appropriate to call the explanation

A. a deduction. **B.** a scientific law.
C. an hypothesis. **D.** a general theory.
E. an example of inductive reasoning.

32. (1.23) Avogadro's suggestion that, "In some elements molecules might be identical with atoms but that in other elements, as well as in compounds, each molecule might consist of several elements," is a good example of

A. a conceptual scheme which could not be directly tested or proved.
B. a hypothesis that had some truth in it, but, in general, had little consequence.

C. a conceptual scheme that had an immediate application.
D. a concept that had no practical use
E. a hypothesis that led directly to new knowledge.

For items 33 - 35 evaluate the following statements according to the key.

KEY

A. An exact scientific law.
B. A general statement with only a few scientific contradictions.
C. A theoretical explanation advanced to explain or account for observed experimental results.
D. A correct definition. **E.** A false statement.

33. (1.23) Molecules attract one another at certain distances but will repel one another if placed too close to each other.

34. (1.23) The heat necessary to raise the temperature of 1 gram of water under standard conditions from 14½°C. to 15½°C. is one calorie.

35. (1.23) The velocity of a body moving in a straight line under constant acceleration is expressed by the equation $V = V_o + at$.

Items 36 - 38 involve terms used in science. Select from the key the most closely related term for each item.

KEY

A. Definition. **B.** Observation. **C.** Theory.
D. Verification of hypothesis. **E.** Natural law.

36. (1.23) About 1887 Congress passed a law making the yard 3600/3937 of the standard meter.

37. (1.23) In every sample of any compound substance, formed or decomposed, the proportion by weight of the constituent elements is always the same.

38. (1.23) The molecules of an electrolyte are broken up in solution into their constituent radicals, each being charged.

39. (1.23) In solution, all electrolytes break down into atoms or groups of atoms carrying positive or negative charges. This is classified as a/an

A. hypothesis. **B.** theory. **C.** definition.
D. natural law. **E.** unverifiable hypothesis.

40. (1.23) By obtaining knowledge through the logical processes of reason, we are using

A. authoritarianism. **B.** rationalism.
C. intuitionalism. **D.** experimentalism.

Items 41 - 49. *Read the following selection carefully.*

The northwestern tip of Quebec, just south of Baffin Island, is flat, sodden tundra sprinkled thickly with little lakes. Most of them are irregularly shaped. But Prospector Fred W. Chubb noticed, while poring over an aerial photograph, that one lake was almost round and surrounded by a wall of rock. This week Dr. V. B. Meen, field geologist Ontario Department of Mines, returned from a quick air visit to the lake and reported that it was almost certainly a meteorite crater (there was no lava or other sign of volcanic activity), and the biggest yet discovered. The lake in the crater is two and one-half miles across, compared with Arizona's famed meteorite crater, which is four-fifths of a mile across. Its level is about 90 feet above that of other small lakes in the vicinity, and around it is a ring of shattered granite that rises 550 feet above the tundra. The rim is lowest on the north-west side, which suggests that the meteorite came from that direction and hit the ground obliquely.

Dr. Meen found no meteoric iron, only a reddish rock that might prove to be the peculiar stony material of which some meteorites are made. But there was plenty of other evidence that some enormous body had buried itself in the earth: shattered blocks of stone from football to freight-car size, and concentric circles in the granite around the crater, like ripples stirred up by a pebble dropped into still water. Dr. Meen estimated that the meteorite must have fallen at least 3,000 years ago, since there are no Indian or Eskimo legends about it. He named it Chubb Crater after the sharp-eyed prospector, and promised that a full dress expedition would report on it within a year. *Time*, August 14, 1950. By permission. Copyright Time, Inc., 1950.

Directions: For each of the items 41 - 49 select the best answer, then mark the corresponding space on the answer sheet.

41. (1.23) The basic problem which faces a scientist in the case of this lake is the

A. shape of the lake. **B.** size of the lake.
C. high elevation of the lake.
D. origin of the lake. **E.** depth of the lake.

42. (1.1) This problem was suggested by the

A. shape of the lake. **B.** size of the lake.
C. high elevation of the lake.
D. origin of the lake. **E.** depth of the lake.

43. (6.1) Which one of the following statements is *least* related to the basic problem?

A. "The northwestern tip of Quebec . . . is flat, sodden tundra, sprinkled thickly with little lakes."
B. ". . . one lake was almost round, and surrounded by a wall of rock."
C. "There was no lava or other sign of volcanic activity."
D. "Its level is about 80 feet above that of other small lakes in the vicinity, and around it is a ring of shattered granite that rises 550 feet above the tundra."
E. (There were) "concentric circles in the granite around the crater, like ripples stirred up by a pebble dropped into still water."

44. (2.2) Which one of the following statements would represent the attitude of a scientist?

A. He would not say that the lake was of meteoric origin unless he had seen the meteor fall.
B. He would say that the lake was of meteoric origin if he had any evidence that pointed in that direction.
C. He would say that the lake was probably of meteoric origin if evidence from many different sources pointed in that direction.
D. He would state that the lake was of meteoric origin and then would attempt to prove it.
E. The economic conditions of the regions would influence his interest in the origin of the lake.

45. (1.23) The statement "It was almost certainly a meteorite crater" is

A. a scientific fact.
B. evidence in support of a scientific fact.
C. an unfounded assumption.
D. a reasonable hypothesis. **E.** a chance guess.

46. (6.2) Which one of the following lines of study would probably furnish the most conclusive means of testing the idea of meteoric origin of the lake?

- **A.** Compare the lake with other lakes in the immediate vicinity.
- **B.** Accurately survey the lake and territory immediately around it.
- **C.** Look for other lakes like this lake in other parts of Quebec and Baffin Island.
- **D.** Compare the lake in detail with known meteoric craters.
- **E.** Determine the structure and composition of the rock found in the vicinity of the lake.

47. (1.23) Which one of the following statements is the best example of an hypothesis?

- **A.** "Dr. Meen found no meteoric iron, only a reddish rock that might prove to be the peculiar stony material of which some meteorites are made."
- **B.** "The rim is lowest on the northwest side, which suggests that the meteorite came from that direction and hit the ground obliquely."
- **C.** "Prospector Fred W. Chubb noticed . . . that one lake was almost round and surrounded by a wall of rock."
- **D.** "The lake in the crater is two and one-half miles across, compared with Arizona's famed meteorite crater, which is four-fifths of a mile across."
- **E.** Dr. Meen "promised that a full-dress expedition would report on it within a year."

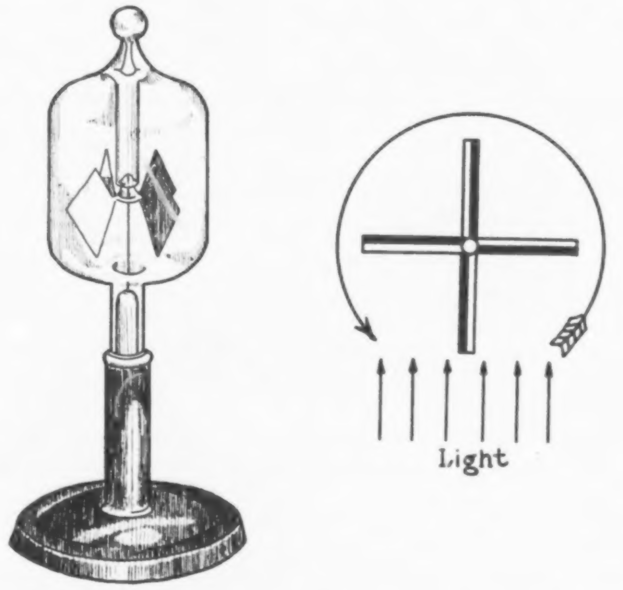
48. (2.3) The face of the moon shows many craters similar to the Chubb and Arizona craters, most of which are larger than either of these. If these craters on the moon were formed by meteorites, why are there fewer of them on the earth?

- **A.** The moon has no atmosphere, and therefore there is no erosion working on the moon to destroy the craters.
- **B.** More meteorites strike the moon than the earth, because the moon is located out in space where the meteorites can reach it more easily.
- **C.** The moon is smaller than the earth and therefore the moon is more susceptible to being buffeted by meteorites.
- **D.** The natural laws that operate on the earth do not operate on the moon.
- **E.** The moon is older than the earth, and therefore has had more time for meteorites to strike it.

49. (3) According to some theories of the origin of the solar system the earth and moon and other planets and their moons were formed at one stage by a process in which the larger fragments picked up the small ones as they all traveled around the sun. According to this, the present occurrence of meteorites on earth is merely a vestige of the much greater bombardment which took place in earlier days. Following out this idea

- **A.** the moon is now being bombarded as the earth was in its early history.
- **B.** the moon's surface has retained the effects of early bombardment.
- **C.** the role played by meteorites in the formation of the moon is not the same as in the formation of the earth.
- **D.** the chances of a large meteorite striking the moon are considerably greater than of one striking the earth.
- **E.** large meteorites strike the earth now only in remote, uninhabited places.

Items 50 - 70.



A number of years ago Sir William Crookes perfected an instrument which always intrigues people, whether laymen or scientists. This is the radiometer, a device consisting essentially of a paddle wheel which is free to rotate in a horizontal plane within a partially evacuated glass bulb. One side of each paddle is brightly polished, while the other side is coated with lampblack. As soon as the device is placed in sunlight, the little paddle wheel starts to spin rapidly, and continues to spin until the device is again placed in the dark. The cause of the motion was at first obscure. The development of a satisfactory explanation is a good illustration of the scientific method of thinking. Listed below are various phases of scientific thinking.

Group I

- **A.** Formulating a problem.
- **B.** Deciding to use or using established scientific principles in attacking a problem.
- **C.** Proposing one or more hypotheses.
- **D.** Obtaining data by observation or experiment.
- **E.** Rejecting an hypothesis as inadequate.

Group II

- **A.** Planning an experiment.
- **B.** Deriving a specific conclusion from an experiment.
- **C.** Organizing a theory from conclusions or hypotheses shown to be true.
- **D.** Recognizing that new information obtained by experiment requires modification of the theory.
- **E.** Making a theory modification on the basis of new data.

Below you will find the record of the various steps followed by two students, John and Ralph, in working out an explanation for the motion of the radiometer. After the number on the answer sheet which corresponds to that of each item, blacken the one lettered space which designates the particular phase of scientific thinking (listed above) that is *best* illustrated by that item. (Where the number I appears after the item number choose your answer from group I. Where II appears choose from group II. Where part of an item is underlined, judge the underlined part.)

50. (1.25) I John and Ralph saw that the radiometer turned only when exposed to light. Increasing the intensity of the light source or bringing the light source closer to the radiometer caused the vanes to turn faster.

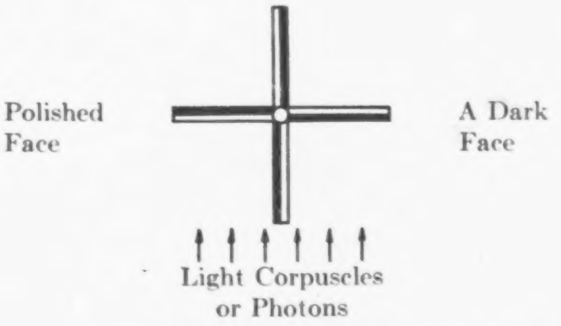
51. I The vanes stopped completely when the instrument
(1.25) was placed in the dark.

52. I It was obvious to the boys that the motion of the
(1.25) vanes somehow depended upon the receiving of light, but why did motion result?

53. I John observed that the vanes in motion represent
(1.25) energy and that, since this energy must come from some outside source, it should be possible to work out some satisfying explanation for this motion. Ralph immediately proposed that they apply their knowledge of the laws of energy, including their knowledge of light.

54. I John suggested that some scientists believe that light consists of streams of corpuscles, or photons, and that perhaps these corpuscles stream through the glass and, by collision, transfer their energy to the vanes.

55. I Ralph vigorously objected, because he reasoned that
(1.25) at any one moment as many corpuscles would be colliding with a polished face as with a dark face, and this would result in no motion. He said that collisions on the dark face, as illustrated in the diagram below, would represent a turning force canceling the force of the collisions on the polished face. John felt that the reasoning of Ralph was valid and agreed to pursue another tack.



PADDLE WHEEL FROM ABOVE

56. I Ralph now raised this question: Is the motion de-
(1.25) pendent upon having the vanes polished and blackened on opposite faces?

57. I A manufacturer of radiometers kindly demonstrated
(1.25) to them that a similar instrument with only bright vanes or only blackened vanes did not turn when illuminated.

58. II This firmly convinced Ralph that the motion is defi-
(1.25) nitely due to the peculiar construction of the instrument which made possible the conversion of light energy to kinetic energy.

59. I He proposed that they reason from the fact that light
(1.25) is energy traveling in waves and undergoing such phenomena as reflection and refraction.

60. II John suggested that they place a mirror in front of
(1.25) the radiometer to reflect the light rays away from the radiometer and that they observe whether this would cause the vanes to stop moving.

61. I When they tried this, the vanes actually ceased
(1.25) moving.

62. II They then agreed that light energy was converted
(1.25) into kinetic energy within the instrument.

63. I The boys were then perplexed until, in reading fur-
(1.25) ther on the subject of light, they came across the statement that a thermometer with a blackened bulb will record a higher temperature than an ordinary thermometer. This would suggest the possibility that light energy would be converted into ordinary heat on contact with a dark face of the radiometer vanes.

64. I Furthermore, maybe a polished face would reflect
(1.25) light energy, but a dark face would absorb it and become warmer thus causing increased motion of the air molecules close to the dark face and resulting in increased bombardment on the dark face, propelling it away from the light.

65. I Ralph asked the instrument maker if the motion of
(1.25) the vanes was in any way dependent upon the amount of residual air left in the radiometer. He was shown an instrument not working because too great a vacuum had been created.

66. II The boys now agreed that their understanding of
(1.25) this device might be summed up as follows: visible light travels through the glass walls, is reflected at the polished faces, and is absorbed by the blackened faces. On contact with the blackened faces, the light is converted into heat energy and, in this form, increases the heat energy of air molecules on these faces, with the result that the blackened faces travel in a direction away from the light rays.

67. I A friend suggested that infra-red rays are a form of
(1.25) light, so-called invisible light, and are given off by any warm object such as a flatiron. Can infra-red rays take the place of light in this instance?

68. I The boys placed a radiometer in front of a warm
(1.25) flatiron and found to their amazement that visible light was not necessary to cause motion, for the vanes turned vigorously in the dark in front of the flatiron.

69. II The boys were temporarily confused because some-
(1.25) thing other than visible light caused the vanes to rotate.

70. II Then Ralph remarked, "Why this is simple. Infra-
(1.25) red and visible light are two forms of the same thing, radiant energy. Radiant energy is absorbed by black surfaces and converted to heat energy of moving molecules. It is radiant energy which is passing through the glass walls and operating the radiometer."

71. The initial step in the general pattern of scientific think-
(1.25) ing is the
A. setting up of an hypothesis.
B. collecting of observational or experimental data.
C. application of a general principle.
D. recognition and definition of a problem.
E. testing of an hypothesis.

72. The connection between a conceptual scheme and an
(1.25) experimental test is usually by means of
A. a hypothesis on a grand scale.
B. brilliant flashes of imagination, or "hunches."
C. accidental chains of discoveries.
D. inductive, rather than deductive reasoning.
E. a whole chain of reasoning.

73. From numerous observations that application of pres-
(1.25) sure to various gases always results in proportionate decreases in their volumes, providing the temperature does not change, Robert Boyle concluded that "at con-

stant temperature the volume of a gas varies inversely with the pressure." This *best* illustrates

A. testing of an hypothesis.
B. reasoning from the abstract to the concrete.
C. deduction from a scientific law.
D. formulation of an hypothesis.
E. use of inductive reasoning.

Items 74 - 82 are related to the following article which is reprinted by permission from *Time* Magazine; copyright 1950, Time, Inc. Read this article carefully before attempting to answer the items.

Until Irving Langmuir began poking into the subject, meteorology was a passive science. Meteorologists observed and tried to forecast the weather, but when asked why they didn't do something about it, they simply looked reproachful. . . . No meteorologist to begin with, Brooklyn-born Irving Langmuir was educated at Columbia University and Göttingen in Germany. In 1909 he joined General Electric Research Laboratory where he found the freedom he wanted to do research. His G. E. bosses told young Langmuir not to bother about practical applications of his experiments, to look around the laboratory and work on anything that interested him.

. . . Like everyone else, Langmuir did nothing about the weather . . . until World War II, when he began studying the water droplets in high, cold clouds which freeze into deadly ice on airplane wings. . . . The schoolbook explanation of rain is that "clouds condense into raindrops and fall to the ground." It is not quite as simple as that. Unless something special happens to it, a cloud remains a cloud; the droplets in it stay about as they are, too small to fall.

After the war, Langmuir went back to work on the mystery of rain clouds. He knew that the droplets in clouds do not freeze at 0°C. (32°F). They are supercooled, i.e., are much colder than zero Centigrade, the normal freezing point. When an ice crystal comes in contact with supercooled droplets, it can steal water from them, so water vapor moves from the droplets to the ice. The ice crystals grow; the droplets shrink. Langmuir reasoned, as others had before him, that this process might be a cause of rain and might show a way to make artificial rain. If small ice crystals could be induced to form in a supercooled cloud they should grow into big snowflakes at the expense of the cloud's droplets, then fall to the ground as snow, or melt into rain.

Langmuir and his brilliant young protégé, Vincent Schaefer, . . . settled down in G. E.'s Schenectady laboratory and began experimenting. Langmuir and Schaefer tried all kinds of things, with no success. Then one hot day in July, 1946, Schaefer was alone in the laboratory. The cold chamber was not quite cold enough to suit him, so he put in a hunk of dry ice (temp. −79°C, −110°F). At once he saw bright motes swirling through the light beam. As he watched, they grew into glittering snowflakes and settled to the bottom of the chamber.

Langmuir, the man of theory, soon worked out the "mechanism." It was the low temperature of the dry ice, not its carbon dioxide, that did the trick. Any very cold object, e.g., a needle cooled with liquid air, served as well. How cold is cold enough? Langmuir and Schaefer found by careful experiment that the motes form at −39°C. (−38°F.). This explained some types of rain. Certain clouds rise high enough to be cooled to that temperature. Ice motes form, find their way into warmed parts of the cloud, where they grow into snowflakes and fall as snow or rain. "Why not help things along with some dry ice?" asked Langmuir and Schaefer.

One day in November, 1946, Schaefer took off from Schenectady in a small airplane and directed the pilot to a fleecy cloud four miles long that was floating over nearby Massachusetts. When he reached it, he scattered into the cloud six pounds of dry ice. Almost at once the cloud, which had been drifting along peacefully, began to writhe as if in torment. White pustules rose from its surface. In 5 minutes the whole cloud melted away, leaving a thin wraith of snow. None of the snow reached the ground (it evaporated on the way down) but the dry ice treatment had successfully broken up a cloud.

Directions: For each of the items 74 - 82 select the best answer, then mark the corresponding space on the answer sheet.

74. General Electric, in telling Dr. Langmuir not to bother
(1.1) about the practical applications of his experiments, was

A. violating the best principles of scientific research.
B. trying something new which is not ordinarily followed by scientists.
C. running a serious risk of losing the money they were investing in his salary.
D. pursuing a policy which in many cases has led to something valuable.
E. doing something which was likely to be successful in Dr. Langmuir's case but might not be so in the case of most scientists.

75. In approaching the question of rainfall, the primary
(4.1) problem was

A. whether or not artificial rain could be made.
B. whether or not it would be ultimately desirable to make artificial rain.
C. how cloud droplets become rain drops.
D. how clouds get cold enough for forming rain.
E. whether or not artificial cloud drops could be made in the laboratory.

76. Dr. Langmuir recognized that the key phenomenon in
(4.1) the rain-producing process was the

A. growth of the ice crystals.
B. supercooling of water droplets.
C. shrinkage of the water droplets.
D. melting of the snowflakes.
E. movement of the cloud.

77. Which one of the following statements indicates how
(1.25) the hypothesis for the problem of rain formation was
tested?

A. "Langmuir and brilliant young protege Vincent Schaefer, settled down in G. E.'s Schenectady laboratory and began experimenting."
B. "Then, one hot day in July, 1946, Schaefer was alone in the laboratory. The cold chamber was not cold enough to suit him, so he put in a hunk of dry ice."
C. "Langmuir reasoned . . . That this process might be the cause of rain, and might show a way to make artificial rain."
D. "One day in November, 1946, Schaefer took off from Schenectady in a small airplane, and directed the pilot to a fleecy cloud. . . . When he reached it, he scattered into the cloud six pounds of dry ice."
E. "None of the snow reached the ground . . . but the dry ice treatment had successfully broken up the cloud."

78. (1.23) Which one of the following statements constitutes a conclusion drawn by Langmuir and Schaefer as a result of their observation or experimentation?

A. "When an ice crystal comes in contact with supercooled droplets, it can steal water from them, so water vapor moves from droplets to the ice."
B. "Almost at once the cloud, which had been drifting along peacefully, began to writhe as if in torment."
C. "At once he saw bright motes swirling through the light beam. As he watched, they grew into glittering snowflakes and settled to the bottom of the chamber."
D. "It was the low temperature of the dry ice, not its carbon dioxide that did the trick."
E. "Why not help things along with dry ice?" asked Langmuir and Schaefer.

79. (1.25) A scientist attacking a problem like Dr. Langmuir's will tend to

A. develop a strong conviction of the correctness of his point of view, and look for data to prove it, discarding those which do not agree with it.
B. reach a conclusion after a thorough examination of the data and, after he has tested his conclusion, discard any later data which do not agree with it.
C. modify his conclusion when necessary to make it agree with new data as these become available.
D. refrain from drawing any conclusion since he obviously cannot examine all of the data related to his problem.
E. withhold efforts to make practical applications of his experimental results until these results have provided a final solution to the problem.

80. (2.2) Dr. Langmuir's rain-making activities as reported involved

A. disregarding accepted natural laws.
B. making use of already-existing natural laws.
C. breaking natural laws.
D. changing natural laws.
E. performing an operation outside the realm of natural law.

81. (2.1) Which one of the following sentences best describes Dr. Langmuir's attitude in connection with the problem?

A. He was certain from the beginning of his investigation what the final results would be.
B. He believed that the formation of rain is the result of the interaction of an intricate set of natural phenomena.
C. He began the experiments with little or no idea that they might eventually result in an understanding of the formation of rain.
D. He was interested mostly in the practical aspects of the problem.
E. He believed the problem was soluble by purely theoretical means.

82. (6.2) Research in artificial rain-making

A. is of little concern to the average citizen because it is so technical.
B. was an initial mistake and never should have been started, because of the political bickering and legal tangles which were bound to develop.
C. was innocently begun but should be made illegal together with the practice of artificial rain-making.
D. should be pursued by the federal government as project number one of all current research and development projects.
E. should be continued actively by all interested groups with resources available.

Items 83 - 88. *Read the following selection carefully.*

At a temperature of 0° Centigrade and standard barometric pressure there are about 27,000,000,000,000,000,000 molecules in one cubic centimeter of air. These molecules are in constant motion, and have an average velocity of about one-quarter of a mile per second. This is slightly greater than the speed of sound. Under these conditions the average distance traveled by a molecule before it strikes another is eight millionths of a centimeter.

In interstellar space a molecule is believed to travel about 50 billion miles before it collides with another. Each molecule in space collides with another on the average of about once a year. *Directions:* For each of the following items select the best answer and mark the corresponding space on the answer sheet.

83. (6.2) The statements in the selection are

A. wild guesses.
B. true, because they are based on statements in a reputable textbook.
C. incredible, because no one can even see molecules, much less measure their speeds and numbers of collisions.
D. probably close to the truth because they are the results of calculations based on a well-established theory.
E. incredible, because no one has ever been able to travel to interstellar space.

84. (1.23) The statements in the selection are

A. observed facts.
B. generalized presentations of fact.
C. hypotheses. **D.** reasoning based on a theory.
E. experimental data upholding or disproving an hypothesis.

85. (1.25) The statements in the selection are obtained by the process of

A. experimentation. **B.** generalization.
C. observation.
D. reasoning from specific data to a principle.
E. applying a general principle to a specific case.

86. (6.2) The statements in the selection are

A. impossible to prove or disprove because one cannot see or handle individual molecules.
B. impossible to prove or disprove because no instruments are available to measure such distances or speeds.
C. possible to check experimentally by direct methods.
D. possible to check experimentally by indirect methods.
E. impossible to check because of the very large and very small numbers involved.

87. (2.2) If the statements about molecules are true,

A. the average distance a molecule travels between collisions is large in comparison to its diameter.
B. there is much more space occupied by molecules than between molecules in the air.
C. when one molecule strikes another, the first one is destroyed.

D. the distances between molecules are small compared to their diameters.
E. each molecule always travels at the same speed.

88. (2.2) If the statements in the selections are true, which one of the following is *inconsistent* with them?

A. Matter must be evenly distributed in interstellar space.
B. Man can build a machine which will travel as fast as an average air molecule.
C. Probably in air few molecules travel as far as one centimeter before colliding with others.
D. In interstellar space, molecules travel an average distance of 50,000,000,000 miles before changing directions.
E. Interstellar space is a complete vacuum.

89. (1.24) A scientific theory is usually established when

A. it agrees with about half of the observed experimental facts.
B. it is based on plain common sense.
C. almost every person believes it.
D. about half of the leading scientists accept it.
E. it accounts for every bit of experimental evidence known at the time.

90. (1.25) A geologist, in attempting to prove a theory:

A. looks only for evidence that supports the theory.
B. limits his evidence to observations in easily accessible localities.
C. records any observations that prove or disprove the theory.
D. builds on previous concepts despite new evidence.
E. supports and correlates all evidence with a geologic map.

91. (1.23) The earliest investigator in this field observed after one experiment that water boiled at 100° Centigrade (212°F). He concluded that water would always boil at this temperature. His conclusion may be classified as
A. a proven fact. **B.** a scientific law.
C. a deliberate lie. **D.** a haphazard guess.
E. an invalid assumption.

92. (1.24) Which one of the following statements is *incorrect?*

A. All landscapes are due to a combination of three important factors in geology: structure; process; time.
B. Some small features of the landscape may change in appearance during a man's lifetime.
C. There are some things about the earth which, as yet, have not been satisfactorily explained.
D. Once an experienced geologist has examined an area and given an explanation concerning the geologic development of that area it is certain that no younger, less experienced man can find anything to change the story published by the geologist.
E. Certain processes make definite records different from those produced by other processes; other processes may produce records that are similar to the records produced by entirely different processes.

93. (1.23) A satisfactory scientific hypothesis

A. is a collection of accurate observations relating to the same phenomenon.
B. is an imaginative guess which explains a large number of observations or a scientific law and can be subjected to further experimental test.
C. is a summary, often in the form of an equation, of a series of related measurements.
D. is the name given to a theory which has survived a large number of experimental tests.
E. is necessary before any accurate scientific measurement can be made.

94. (1.25) The scientific method

A. begins with the formation of reasonable hypotheses.
B. is applied only to the natural sciences.
C. deduces facts only on the basis of the laws which have been discovered.
D. evolves laws to fit the theories which have been established.
E. proceeds in the following order; fact, law, hypothesis, theory.

95. (1.25) Logic, both inductive and deductive, is a necessary part of scientific thinking; but its conclusion must

A. be accepted beyond question.
B. always be tested by experiment.
C. be based upon a few observations.
D. never be used today.
E. be accepted whenever the scientist presenting the theory is an authority in his field.

96. (1.25) In order to help determine the existence of a degree of order and organization in a constantly changing environment, *certain methods of investigation* have been emphasized especially in connection with the studies on physical and chemical changes and the derivation of two of the Gas Laws. These methods are

A. obtaining data, classifying the data, and then placing it on graphs.
B. identification, recognition and classification of dynamic relationships between quantities.
C. identification of all variables involved, then keeping one variable fixed while others are varied one after another.
D. direct and inverse comparisons of observed differences.
E. application of external agents, careful observation of results, and formulation of hypotheses leading to fruitful investigations.

97. (1.3) Both Archimedes and Galileo treat matter as consisting of "parts." Does the concept of "part" have the same implication in both treatments?

A. Yes; a physically existent ultimate particle is implied in both.
B. Yes; an arbitrarily bounded segment is implied, but not a real entity.
C. Yes; both treatments rest on the assumption that matter is discontinuous.
D. No; the parts in Archimedes are arbitrarily bounded but those in Galileo are considered as real units of matter.
E. No; only in Galileo are parts defined in such a way that they may be investigated experimentally.

98. (2.00) Which of the following assumptions is most essential in Lavoisier's scheme of classification?

A. All acids contain oxygen.
B. Mass is conserved in chemical change.
C. The properties of compounds are due to their composition.

D. The compounds possess the properties of the elements from which they are formed.
E. Particles exist which are undecomposable.

99. (2.1) Which of the following basic techniques of science is best exemplified by Galileo's experiment designed to determine the force needed to break a column of water?

A. The separation and estimation of the factors involved in a complex situation.
B. The extrapolation of measurements to situations in which data cannot be obtained directly.
C. Experimental test of a proposition derived from a theoretical postulate
D. Collection of data on a variety of subjects for the purpose of classification and eventual interpretation.
E. Experimental test of the validity of the derivation of a proposition from a postulate.

100. (2.1) Which of the following involves the use of the same basic technique?

A. Archimedes' derivation of propositions from a basic postulate.
B. Berthollet's refutation of Bergmann's theory of affinities.
C. Gay-Lussac's derivation of his generalization concerning reacting volumes of gases.
D. Cannizzaro's method of arriving at atomic weights.
E. None of these procedures is similar.

101. (2.1) In Lavoisier's determination of the composition of air, the experiment in which mercury was calcined in the presence of a restricted amount of air is best considered to be

A. a complete analysis of the air.
B. a step in an analysis of the air.
C. a step in a synthesis of the air.
D. a complete synthesis of the air.
E. simultaneous analysis and synthesis of the air.

102. (2.1) The subsequent experiment in which the red calx of mercury was heated in the absence of air is best considered to be

A. a complete analysis of the air.
B. the final step in a partial analysis of air.
C. the final step in a partial synthesis of air.
D. the final step in a complete synthesis of the air.
E. none of the above.

103. (2.1) The heating of the red calx of mercury can also be looked on as

A. an analysis of the mercury.
B. a synthesis of the mercury.
C. an analysis of the mercuric calx.
D. a synthesis of the mercuric calx.
E. a part of the synthesis of the mercuric oxide.

104. (2.1) A scientist thinks that he understands why a certain cause produces a certain effect, but he refuses to more than tentatively accept his explanation until he has collected adequate data. It is evident from the above alone that this scientist possesses

A. scientific attitude. **B.** common sense.
C. scientific knowledge.
D. the correct solution to his problem.
E. a willingness to rationalize.

105. (2.1) A truly scientific experiment can always be characterized as

A. dealing only with living things.
B. peculiar to the field of investigation.
C. having no possibility of being duplicated.
D. having a basis for comparison of results.
E. being conducted only in a laboratory.

106. (2.1) The observation of data without allowing one's personal motives to "color" the observations is known to social science as

A. intuition. **B.** objectivity. **C.** subjectivity.
D. bias.

107. (2.2) In terms of Lavoisier's criteria for adequate chemical evidence, proof that ordinary air is composed of the two parts, "mephitis" and "highly respirable air," requires that Lavoisier

A. use no more than the results of the experiments mentioned in 101 and 102.
B. prove that "mephitis" and "highly respirable air" cannot themselves be separated into any more substances.
C. show that no substance other than air is composed of "mephitis" and "highly respirable air."
D. show that "mephitis" and "highly respirable air" can each be obtained from other compound substances, although not necessarily from the same compound substances.
E. show that when "mephitis" and "highly respirable air" only are combined in the proportions in which they were obtained from air, the mixture behaves in all ways as air.

108. (2.00) For Lavoisier, the discovery that "mephitis" is a compound substance would

A. overthrow Lavoisier's entire system of nomenclature based on the concept of elements.
B. necessitate the revision of the nomenclature of azote and its compounds, if azote is identical to "mephitis."
C. indicate that the analysis-synthesis criteria are insufficient to determine the composition of a substance.
D. indicate that air is not composed of "mephitis" and "highly respirable air."
E. indicate that the "highly respirable air" is also a compound substance.

109. (2.2) Krauskopf states that, "Electricity and magnetism, just in the fact of their existence, do violence to our intuitive ideas of matter, space, and the nature of force." In making this statement he probably had in mind the fact that

A. we cannot formulate laws which can be used to make valid predictions.
B. they really exist only in our minds as scientific abstractions.
C. they have not been fruitful in extending research.
D. they act without contact across intervening space.
E. they do not alter the space around them.

110. (2.2) Considering only the experiment (Lavoisier, pp. 77 - 79) in which water is distilled from one vessel through an empty tube at red heat into a second vessel, one can definitely conclude that

A. water is not a mere physical mixture of two substances.
B. "red" heat alone does not decompose water.
C. steam cannot be raised to a temperature higher than the boiling point of water.

- **D.** once caloric has combined with the particles of a liquid to form a gas, no further caloric can be added to the gas.

111. (2.2) Consider only an experiment in which water is distilled from one vessel, through a tube containing charcoal at red heat, into a second vessel. The charcoal disappears and the only other observations made are that water is not present in the second vessel but certain quantities of two gases, one of which is called "carbonic acid gas," are present. From this alone, one can definitely conclude

- **A.** that charcoal combines with oxygen to form carbonic acid gas.
- **B.** that water contains oxygen and another substance.
- **C.** that charcoal is a combination of hydrogen and oxygen and some other substance.
- **D.** that hydrogen is a compound substance.
- **E.** none of the foregoing.

112. (2.2) Considering together only the two experiments mentioned in the two preceding questions and assuming that the second gas contains no carbon, one can definitely conclude that

- **A.** water contains oxygen and another substance.
- **B.** hydrogen is a compound substance.
- **C.** water is a compound substance, one of whose components is hydrogen.
- **D.** charcoal is a compound substance.
- **E.** either water or charcoal, or both, is a compound substance.

113. (2.00) In order to prove that water is decomposed into oxygen and another gas

- **A.** no evidence beyond that given by the two experiments mentioned in items 110 and 111 is needed.
- **B.** it is necessary also to prove that the other gas is not a compound substance.
- **C.** it is necessary also to prove that carbonic acid gas is composed of charcoal and oxygen.
- **D.** it is necessary also to prove that iron also decomposes water into hydrogen and oxygen.

Items 114 - 124. Mark space

- **A.** if the statement has been proved by experiment or observation.
- **B.** if the statement is theoretical or hypothetical.
- **C.** if the statement is a definition.
- **D.** if the statement has been proved false by experiment or observation.

114. (2.4) The mass of 1 cc of water at 4°C is one gram.

115. (2.4) The pressure of a gas is due to the motion of the molecules.

116. (2.4) The gravitational attraction is the same at all places on the surface of the earth.

117. (2.4) The number of different kinds of atoms is limited.

118. (2.4) The earth's diameter is greater at the equator than at the poles.

119. (2.4) Heat is the kinetic energy of rapidly moving molecules.

120. (2.4) The acceleration of a body is equal to the time rate of change of velocity.

121. (2.4) The mass of a hydrogen atom is 100 times that of an electron.

122. (2.4) An electric current may be produced in a coil of wire by moving a magnet into the coil.

123. (2.4) The number of molecules in a liter of any gas is the same as the number in a liter of any other gas under the same conditions.

124. (2.4) Wave motion transmits energy.

125. (2.3) The lowering of the temperature of a liquid by evaporation was probably first discovered by

- **A.** deducing the consequences of the kinetic theory.
- **B.** controlled experimentation. **C.** speculation.
- **D.** observation. **E.** inductive reasoning.

Questions 126 - 130 refer to the following paragraphs:

Lavoisier demonstrated the falsity of the Phlogiston hypothesis most clearly by a series of experiments on tin, a metal which is readily converted to a white powder by heating. He repeated the simple experiment of weighing the tin before and after heating, to show that the powder weighed more than the metal. He placed a little tin on a wooden block floating in water, covered the block with a glass jar, and heated the tin by focusing the sun's rays upon it with a magnifying glass. Part of the tin was converted to a white powder and the water level rose in the jar until only four-fifths as much air was left as at the start; further heating caused no detectable change. Finally tin was heated in a sealed flask until as much as possible was converted to a powder. The flask was accurately weighed before and after heating, and the two weights proved to be identical. Then the flask was opened and air rushed in. With the additional air, the weight of the flask was greater than at the start.

126. (2.1) The experiment described in the reading passage states that when the tin was heated

- **A.** it absorbed a gas or gases from the air.
- **B.** some of the air had been used up in the heating process.
- **C.** some of the air in the vessels had been compressed by the heating process.
- **D.** none of the above would be correct.
- **E.** more than one of the above would be correct.

127. (2.3) The experiment described in the reading passage would suggest that when the tin is heated until it is converted to a powder,

- **A.** the resulting powder compresses the volume of air in the containers so that when the flask is opened air rushes in to fill the vacuum.
- **B.** the resulting powder is really a compound of the gas from the air and the original metal.
- **C.** the resulting powder causes the air to divide or separate into its component gases.
- **D.** the chemical process involved in heating the metal to convert it to a powder caused the air in the flask to partially separate into the component gases.
- **E.** more than one of the above is true.

128. (4.2) According to lines 20 and 21 in the reading passage heating the tin in the flask did not result in any change of weight; yet according to lines 21 and 22, when the flask was opened, air rushed in! This would seem to indicate several factors. Which of the following does *not* belong among these factors?

- **A.** Heating the tin has caused part of the original air to be absorbed by the tin.
- **B.** Heating the tin has created a partial vacuum within the flask.
- **C.** Heating the tin has caused both the tin and the air to change their chemical composition.
- **D.** When the flask is opened, the tin is returned to its original state.
- **E.** When the flask is opened, the air rushes in to replace the gas absorbed by the tin.

129. (2.2) The increase in weight mentioned in lines 6, 7 and 8 of the reading passage is due to

- **A.** the expansion of the metal when heated.
- **B.** the expansion of the metal, air, and container when heated.
- **C.** the weight of the gas taken from the air by the tin.
- **D.** the fact that the tin is now powdered, and therefore occupies more volume.
- **E.** more than one of the above is true.

130. (6.2) According to the experiment described in the reading passage, probably the one single factor which, *more than any other,* made possible Lavoisier's discovery of the true nature of combustion was the availability of

- **A.** the metal, tin. **B.** the magnifying glass.
- **C.** a means of accurate weighing.
- **D.** a flask which could be sealed.
- **E.** none of the above.

In the following list of items you may find illustrations of accurate or inaccurate "Observation and Terminology" (mark such items A); "Relativity of Theory and Concept" (you will note a concept and probably know of a theory that weakens or strengthens the concept, mark such an item B); "Cause and Effect" (whether the statement is valid or not valid—mark C); "Teleology, Plan and Order" (mark such a statement D); "Sampling and Extrapolation" (Mark E), and "Authority and Authoritarianism" (mark F).

KEY

- **A.** Observation and Terminology.
- **B.** Relativity of Theory and Concept.
- **C.** Cause and Effect.
- **D.** Teleology, Plan and Order.
- **E.** Sampling and Extrapolation.
- **F.** Authority and Authoritarianism.

131. (2.4) ( ) Atomic bombs set to explode underground will be more effective as a weapon of war than one exploded in the air.

132. (2.4) ( ) The safe way to simulate a great explosion is to use and take data on a "low order" chemical explosion and scale up its effect to theoretically full atomic proportions.

133. (2.4) ( ) An atom bomb detonated under ground would leave a radio-active crater which would be dangerous indefinitely.

134. (2.3) ( ) A gaseous–diffusion plant, such as the new one in the Ohio Valley, may be used to make "enriched" uranium.

135. (2.4) ( ) Plutonium and U 235 have individual virtues.

136. (2.4) ( ) The U. S. is using only 30 percent of its land and less than 10 per cent of its water, says John Grebe, Research Counselor, Dow Chemical Company.

137. (2.4) ( ) Atomic fission in uranium releases neutrons to produce a chain reaction.

138. (2.4) ( ) The Germans had ordered the Norwegian electrochemical plant, Norsk Hydro—largest of its kind in the world—to increase its production of deuterium oxide (heavy water) from 3000 to 10000 pounds per year.

139. (2.4) ( ) Radium was discovered just before the turn of this century, methods for separating isotopes just short of twenty-five years later, and one would expect great discoveries in the area "Nuclear Physics" just short of 1950.

140. (2.4) ( ) Reversed matter? An atom of "anti hydrogen" would have a negative proton as its nucleus, with a positron instead of an electron revolving around it.

141. (2.4) ( ) Since the Weir Pittsburg vein of coal contains more B.T.U. per pound than coal from the other coal seams in this locality, it brings a better price on the market.

142. (2.4) ( ) Jas. Preston Joule gave to the men of science this "mechanical equivalent of heat."

143. (2.4) ( ) Specimens of coal were taken from several locations in a coal mine and in every case the coal was found to have a very high B.T.U. content; any coal from that particular mine is considered good coal when the B.T.U. content is the only consideration.

144. (2.4) ( ) Coal is a more economical source of heat than gas.

145. (2.4) ( ) Coal will float in carbon tetrachloride, a liquid that "has a density greater than coal."

146. (2.4) ( ) A piece of iron heated to the melting point will radiate some ultraviolet radiation.

147. (2.4) ( ) Nature provides us with several coal seams in order that when one seam becomes completely exhausted we have another one available for mining.

148. (2.4) ( ) A person could hook up enough amplifiers and speakers to make recordings sound better than the original performance.

149. (2.4) ( ) The popularity of the Hi-Fi is the reason for manufacturers of sound equipment to speed up research on high fidelity sound.

150. (2.4) ( ) Using high fidelity microphones and making several recordings with the microphones placed at various positions and distances from a sound source until a perfect recording is made will assure a high fidelity performance when played in an auditor's living room.

151. ( ) If Hi-Fi pronounces a recording excellent, you can rest assured that it is excellent.
(2.4)

152. ( ) Manufacturers of sound equipment perfected the graphaphone, then the radio, followed in due time by the juke box, the public address systems, the tape recorder. In order to keep their business alive —in due time they will market "binaural sound" equipment.
(2.4)

Items 153 - 167. In the following key you will find five possible responses. Read each item carefully and select the one of the five responses which is most appropriate. Write its number in the space provided.

KEY

- **A.** The statement is based upon incorrect reasoning.
- **B.** The statement is a reasonable hypothesis.
- **C.** The statement is warranted.
- **D.** The statement is an opinion stated as a fact.
- **E.** The statement is a fact.

153. ( ) Improved methods of generating, transmitting and distributing of electric power have contributed to a reduction of power cost to the consumer.
(1.1)

154. ( ) Improvement of the efficiency of the filament type of electric lamp is steady and sure.
(2.4)

155. ( ) The efficiency of the filament type of electric lamp is lower than any commonly used electrical device.
(2.4)

156. ( ) The people of this country enjoy the best lighting of any people on earth.
(1.1)

157. ( ) The only reason that the forty-watt fluorescent lamp is not as hot to the touch as the forty-watt filament type lamp is because of its greater radiating surface.
(1.1)

158. ( ) Judging by progress made during the past twenty-five years there will be no great improvement in developing high efficiency filament type lamps in the near future.
(2.3)

159. ( ) Research yields good illumination but only the educators of the public are responsible for its acceptance.
(2.4)

160. ( ) A "cold" light will be developed in the near future.
(1.1)

161. ( ) People reared in the United States take good illumination for granted and pay very little attention to improvements in the field.
(1.1)

162. ( ) Edison's first lamp had a very fragile filament, it was high priced, it emitted light for the most part in the long wave length region of the visible spectrum, had a short operating life and was very inefficient.
(1.1)

163. ( ) The keen competition between manufacturers of electric lamps is based upon their desire to make the perfect lamp.
(1.1)

164. ( ) The fluorescent lamp owes its popularity to its very high efficiency.
(1.1)

165. ( ) Nature produces a "cold light;" so will the scientist just as he has perfected other devices.
(1.1)

166. ( ) A very small percentage of power purchased for illumination is converted into light.
(1.1)

167. Consider the following two hypotheses for explaining the origin of the Carolina Bays:
(2.4)

- **A.** Douglas Johnson proposed a complex hypothesis involving underground solution and artesian action which formed ponds or lakes whose shores were modified by wind and wave action.
- **B.** W. F. Prouty proposed that the depressions were originally caused by the shock waves associated with a large swarm of meteorites which struck the earth from the NW; the depressions later filled with water and were modified by wind and wave action.

Below are seven *facts*. Indicate by circling the appropriate letter, which hypothesis each fact supports, according to the key. (Consider that a fact supports a hypothesis if it could have been predicted from the hypothesis before being observed.)

KEY

- **J.** the fact supports primarily the Johnson hypothesis.
- **P.** the fact supports primarily the Prouty hypothesis.
- **B.** the fact supports both hypotheses about equally.
- **N.** the fact supports neither hypothesis.

168. J P B N Many of the craters have remarkable perfect oval or elliptical outlines.
(2.4)

169. J P B N Many craters are highly irregular in outline.
(2.4)

170. J P B N The oval craters have pronounced axial trends near the NW-SE direction.
(2.4)

171. J P B N No fragments of meteorites have been found thus far in or near any of the bays.
(2.4)

172. J P B N A number of craters are found arranged like beads on a chain, along the sites of former beach ridges.
(2.4)

Item 173 deleted.

174. J P B N There is evidence for a good deal of limestone underlying the general Carolina coastal area.
(2.4)

175. A theory widely held in Lavoisier's time was that combustion consisted in the escape of a material substance, phlogiston, from a burning material into the surrounding atmosphere. By which of the following assumptions can the phlogiston theory best account for the fact that a wax candle burns only for a short time in a closed jar, but can be burned again if the jar is opened?
(3.00)

- **A.** The amount of phlogiston in the wax is limited.
- **B.** The atmosphere can become saturated with phlogiston.
- **C.** Part of the phlogiston is in stable combination with the wax.
- **D.** Phlogiston is repelled by the atmosphere under certain conditions.
- **E.** The pressure of the surrounding atmosphere is necessary in order to expel the phlogiston.

176. Which of the following observations is most difficult to explain on the basis of the statements given above about the phlogiston theory?
(3.00)

- **A.** Air in which mercury is heated decreases in volume.
- **B.** Combustion of some substances results in an increase in weight; combustion of others, in a decrease.

C. Air in which mercury is heated is rendered unfit for breathing.
D. Air in which the red calx of mercury is strongly heated supports combustion more vigorously than does ordinary air.
E. If a candle is burned in a closed vessel, the total weight of the contents does not change.

177. On mixing the "mephitic air" with "vital air" in the
(3.00) proportion of 73 to 27, Lavoisier obtained a gas "precisely similar to atmospheric air in all its properties." How can this result, taken by itself, be reconciled with the phlogiston theory?

A. By postulating an excess of phlogiston in mephitic air and a deficiency in vital air.
B. By identifying vital air as phlogiston and mephitic air as dephlogisticated air.
C. By postulating that mephitic air is pure phlogiston.
D. No reconciliation is necessary since the rival theories agree on the interpretation of this result.
E. No reconcilation is possible; this result is incompatible with the phlogiston theory.

178. Davy found that the combining volumes of oxygen with
(3.00) 100 volumes of nitrogen are 49.5, 108.9, and 204.7. From these results Gay-Lussac concluded that the volume ratios are 2:1, 1:1, and 1:2. What justification did Gay-Lussac have for such a conclusion?

A. The measured values are closer to these simple ratios than to any others.
B. Combination in definite proportions had already been established; simple volume ratios are, therefore, to be expected.
C. The other gas reactions studied showed similar clusterings of data around simple ratios.
D. Although subsequent measurements justified the conclusion, these data do not justify it.
E. Natural laws take the simplest possible forms.

179. Rayleigh found that the density of nitrogen isolated from
(3.00) air is about 0.47% greater than that of nitrogen prepared by chemical means. May this difference be regarded as significant?

A. Only if two kinds of nitrogen gas are assumed to exist.
B. Only if this difference is much larger than the experimental error involved.
C. Only if the experimental error is considered to be zero.
D. Any discrepancy among related data must be regarded as significant.
E. This difference is too small to have any real significance.

180. In view of your answers to the preceding two items,
(3.00) what general statement may be made as to the criteria for significance of deviations in experimental data?

A. The point at which deviations are great enough to be considered significant are arbitrarily decided by each investigator concerned.
B. Deviations of less than 1% may be attributed to experimental error but greater deviations are real.
C. Deviations may be considered significant only if they reappear in a great many similar measurements.
D. The only criterion is whether or not the best theory available can account for such deviations.
E. The significance of deviations is determined by the precision of measurement.

181. A photoelectric cell for measuring intensities of light has
(4.2) been constructed on the theory that electrons exist. Calculations based on this theory give correct values for the intensity of light falling on the cell for all values of the current through the cell. If in the future scientists find evidence against the existence of electrons,

A. we should stop using the cell.
B. we should have to reconstruct the cell.
C. we could use the cell but not the electron theory for calculating the intensity of light.
D. we could continue using the electron theory for calculating the intensity of light.
E. none of the above is true.

The following exercise follows the general pattern of scientific thinking. A scientist on observation of a given phenomenon formulates an hypothesis or several hypotheses, which are tentative explanations of the phenomenon. He then thinks about the hypothesis or hypotheses in terms of his data. Finally, he derives from his data and his thinking about the hypothesis or hypotheses a general conclusion, which is his best answer to the problem presented by the phenomenon. Be sure to read the directions carefully and to follow them explicitly. Base your judgments wholly on the information given in the selection. You may refer back to the selection as often as you wish.

As the words imply, a continuous spectrum is a spectrum in which there is a continuous band of colors from one end to the other. This necessarily means that the light source is emitting all frequencies of light between the spectral limits. A bright-line spectrum is a spectrum in which there are one or more vertical lines of light in certain specific positions. This means that the light source is emitting light waves of certain specific frequencies.

In the isolated atom the electrons have certain definite and characteristic motions, which are related to the emission or absorption of light waves of certain specific frequencies. Hence, when atoms are sufficiently far apart, as in a rarefied gas, and are heated to incandescence, the light waves emitted from them produce the bright-line spectrum characteristic of the elements of the luminous source. However, when the natural motions of the electrons of each atom are altered by force due to the presence of nearby atoms, as in the case of a condensed gas, liquid, or solid, the light waves emitted, instead of being of certain specific frequencies, are of numerous different frequencies. Therefore, incandescent solids, liquids, and dense gases produce continuous spectra. Rarefied gases product bright-line spectra. As previously stated, because of the forces exerted upon them by their neighbors, atoms of solids and liquids have their emitting frequency ranges greatly widened. For the same reason their absorbing frequency ranges are likewise widened. On the other hand, since the atoms of vapors and gases at ordinary or low pressures are comparatively free to emit waves of their own natural frequencies, they can absorb waves of those particular frequencies. Consequently, the absorption spectrum of a vapor is a spectrum in which there are dark lines corresponding to the bright lines in the bright-line spectrum that the vapor would yield if it were incandescent.

The spectrum obtained from the glowing carbon of a carbon arc is continuous and has no vertical lines. When sodium metal is heated in a metal spoon held over the flame of a bunsen burner placed below the arc, sodium vapor is produced, which surrounds and to some extent obscures the arc. A dark line then appears in the spectrum of the arc. If the burner and spoon are removed and a tiny piece of sodium is inserted between the terminals of the arc, a bright yellow line instantly appears in the exact position previously occupied by the dark line.

When light from the sun is observed by means of a spectroscope, the continuous spectrum contains a number of vertical lines, which appear dark by contrast with the rest of the spectrum.

PROBLEM: WHAT CAUSES THE RELATIVELY DARK LINES OF THE SOLAR SPECTRUM?

Below are given a series of hypotheses, each of which is followed by numbered statements. After the answer sheet number corresponding to that of each statement, blacken space

A if the statement supports the hypothesis, and this statement is justified by the information given.
B if the statement supports the hypothesis, but this statement is not justified by the information given.
C if the statement contradicts the hypothesis, and this statement is justified by the information given.
D if the statement contradicts the hypothesis, but this statement is not justified by the information given.
E if the statement is not relevant to the hypothesis, or the statement neither supports nor contradicts the hypothesis.

HYPOTHESIS I: Sodium atoms, when vaporized but not heated to incandescence, absorb light waves of a definite frequency.

182. (4.2) Sodium is a metal which ignites easily when vaporized in air.

183. (4.2) When sodium vapor surrounds a carbon arc, a dark line appears in the spectrum of the arc.

184. (4.2) Sodium vapor under the conditions described absorbs light of a definite frequency, because the natural motions of the electrons of each of its atoms are altered by forces due to the presence of nearby atoms.

185. (4.2) After number 185 on answer sheet, blacken space **A** if Hypothesis I is true, or space B if it is false.

HYPOTHESIS II: Incandescent solids yield bright-line spectra.

186. (4.2) The atoms of a solid are so closely packed together that the natural motions of the electrons of its atoms are altered.

187. (4.2) The spectrum of the glowing carbon of the carbon arc in the total absence of sodium is a continuous spectrum.

188. (4.2) Atoms of incandescent solids are far enough apart that the motions of the electrons are unaltered by atomic forces; hence, such atoms yield bright-line spectra.

189. (4.2) After number 189 on answer sheet, blacken space A if Hypothesis II is true, or space B if it is false.

HYPOTHESIS III: The atmosphere of the sun contains atoms less incandescent than the atoms on the surface of the sun.

190. (4.2) A brilliant corona is observed during a total eclipse of the sun by the moon; hence the atmosphere of the sun is more incandescent than its surface.

191. (4.2) The surface of the sun contains spots which are relatively cooler than the rest of the surface.

192. (4.2) During a total eclipse a bright-line spectrum may be obtained from the sun's atmosphere with the bright lines corresponding in position to the dark lines previously observed.

193. (4.2) After number 193 on answer sheet, blacken space **A** if Hypothesis III is true, or space B if it is false.

After the number on the answer sheet which corresponds to that of each conclusion (items 194 - 198) blacken space

A if the conclusion is the best answer to the problem.
B if the conclusion is the least satisfactory answer to the problem.
C if the conclusion is neither the best answer nor the least satisfactory answer to the problem. (Three conclusions should receive this mark).

194. (6.1) The dark lines of the solar spectrum are due to the fact that the atoms of the sun's atmosphere absorb all of the light of certain definite frequencies.

195. (6.1) The relatively dark lines of the solar spectrum are due to the fact that the atoms of the heated and rarefied gases of the sun's atmosphere both absorb and emit light of certain definite frequencies.

196. (6.1) The atmosphere of the sun contains sodium atoms which absorb light of certain definite frequencies and emit light of the same frequencies.

197. (6.1) The atoms of the surface of the sun are incandescent and emit light which gives a continuous spectrum, while the atoms of the sun's atmosphere are not incandescent and thus absorb light of certain definite frequencies.

Items 198 - 200.

"Storage batteries with an expected life at least 40 per cent longer than those currently used are now available. The new batteries use the same raw materials and operate on the same principles as any regular battery; the only difference is the use of 0.1 per cent calcium in place of about 12 per cent antimony as a hardening agent for the alloy grids. The grids function as supporting structures for a battery's active materials; the sponge-lead of the negative plate and the lead peroxide of the positive plate. Eventually failure of a storage battery is usually caused by the corrosion of the positive grid. Although there was little complaint against the lead-antimony storage battery, it had not undergone any radical change in fifty years."

. . . "A word of caution is directed to those who may expect to buy long-life lead-calcium batteries for other uses. The new battery was developed for the specific requirements of the Bell System where the majority of telephone batteries are maintained on a closely regulated floating routine with batteries held at a voltage just sufficient to maintain a full state of charge. Discharge occurs only during the infrequent failures of commercial power. With continual charge and discharge, lead-calcium may be less satisfactory than lead-antimony."

W. B. Thomas, "An Improved Telephone Battery," *Bell Laboratories Record*, March 1951. American Bell Telephone Company.

After each item number on the answer sheet, blacken the *one* lettered space which designates the correct answer.

198. (6.2) This is

A. just one of the many claims which perennially crop up regarding the storage battery.
B. impossible, since 1/10 of 1 per cent of no substance could have as great an effect as claimed.
C. propaganda, no doubt some secret substance is added which the company has not divulged.
D. an example of fruitful and progressive findings.
E. another instance of possibly longer life, but tremendously increased maintenance costs.

199. Assuming that there is something to the claim, it would
(2.3) seem most reasonable that the longer life results from

A. an unsuspected powerful reaction between the calcium and the acid.
B. the calcium alloy showing less corrosion than the regularly used antimony alloy.
C. the oozing out of the calcium.
D. the antimony hastening the breakdown of the lead grids.
E. an improved form of lead with which the calcium is alloyed.

200. This battery is most probably
(2.3)

A. an outgrowth of an organized research program.
B. an outgrowth of a haphazard circumstance.
C. an outgrowth of the work of some genius inventor.
D. simply a dribbling release by big companies which are holding back information right along so as to make more money.
E. a "flash in the pan."

For items 201 - 210 *read the following selection carefully.* It is adapted from *Geology of the Chicago Region,* by J. H. Bretz. *Directions:* In the body of the selection, numbers indicating items 201 - 208 have been inserted. Consider only the **italicized** portion following each number. *Read the selection through completely so that you understand what the author means before you attempt to mark the answer sheet.* (All items 1.23.)

For each number item in the selection, mark space,

A. if the item states observations relevant to the problem.
B. if the item states a conclusion which contradicts an hypothesis.
C. if the item suggests an hypothesis which the author considers satisfactory.
D. if the item suggests an hypothesis which the author considers unsatisfactory.
E. if the item suggests a test of hypothesis.

In order to gain an understanding of how these valleys were made it is necessary to study the different features in the contours of the surfaces of the underlying bedrock. **(201)** *One of these features is seen to be a type of elongated trough or trench which runs at right angles to the present lake shore, and increases in depth toward the lake.* **(202)** *These troughs in the bedrock appear to be true stream valleys.* **(203)** *They lead toward the lake basin.* If they were formed through erosion **(204)** *an agent would then be required whose action would be along a linear course.* This clearly points to running water in the form of stream tributaries to the larger valley in the softer rock which now holds the lake. **(205)** *If these valleys were by any chance gigantic grooves cut by glacial ice,* **(206)** *they should be running in the same general direction as the scratches and smaller grooves which the ice had made on the bedrock,* **(207)** *but this is not the case.* If they were weathered out of belts of weaker rocks, they should run parallel with the edges or ridges of the harder outcropping rock of the formation and correspond roughly to the lake basin. This condition is not found either. **(208)** *It seems safe to assume then that in these valleys Chicagoland has a record of minor preglacial streams which descended the slope of rock of that region.*

Directions: For items 209 - 210 select the best answer and mark the corresponding space on the answer sheet.

209. The main problem discussed in the preceding selection
(2.1) is

A. whether bedrock trenches exist.
B. how the bedrock trenches were formed.
C. how long ago the trenches were formed.
D. whether the lake basin was formed by a glacier.
E. none of the above.

210. The author substantiated his conclusion by
(2.2)

A. showing experimentally that a trench of such a character is produced by a stream.
B. showing that the known facts do not agree with other hypotheses.
C. showing that a glacier might be expected to produce such a trench.
D. showing that weathering might be expected to produce such a trench.
E. none of the above.

211. From facts and principles previously established, one
(4.2) can infer that

1. since the composition of ammonia gas is NH_3, one might reasonably expect the existence of a compound PH_3.
2. since the composition of sulfuric acid is H_2SO_4, one might reasonably expect the existence of a compound $HSeO_5$.
3. since the composition of calcium chloride is $CaCl_2$, one might reasonsably expect the existence of a compound Ra_2O_3.

Which one of the following choices names only the correct inference or infereneces of those above?
A. 1. **B.** 2. **C.** 3. **D.** 1 and 2. **E.** 1 and 3.

Items 212 - 222 refer to the following paragraphs.

Glass is a solid material of great hardness and amazing stability that is made by fusing a batch of dry, powdered, or granular inorganic chemical compounds. Usually, 60% or more of sand with various percentages of two or more oxides of Na, Ca, K, Pb, Mg, and Al is heated in a refractory container, until a bubbling syrup is formed at a blinding white heat by the mutual solution of the metal oxides. Heating is continued at a lower temperature until the bubbles disappear and the syrup becomes homogeneous. Then, if the formula is a good one, if the melting or fusing has been correct, and if the cooling is done properly, the syrup will stiffen continuously from its liquid or molten state at about 2700°F. to a hard, rigid solid at room temperature without any crystallization taking place.

Soda-lime glasses are used for 90° of all glassware. Their raw materials are the least expensive and they are among the easiest to melt and shape.

Lead oxide is a good fluxing agent and in percentages of 20 and 40 it can replace most or all of the lime and some of the soda or alkali content. This gives glasses greater sparkle and makes them easier to cut and engrave. They are used to make fine tableware and art-glass. About 1758, John Dolland realized that the higher index of refraction of a lead glass, that accounts for its higher sparkle and luster, makes possible compound lenses that are achromatic.

Fused quartz or fused silica glass (99.8% silica) can be made by fusing a batch consisting solely of quartz crystals or of sand (impure crystals of quartz). In this type, unfortunately, the fusing or melting temperature is as high (about 3150°F.) as that of the crystalline raw materials. This requires special melting methods and the molten glass is so viscous that it is difficult to make it homogeneous and free of bubbles.

Borosilicate glasses are a type in which the melting point of the silica is lowered by the addition of boric oxide, B_2O_3, and in smaller amount alumina, Al_2O_3, with only the smallest possible amount of alkali. It is intrinsically superior to corrosion and to breakage from heat shock, but is more difficult to manufacture and work. Borosilicates have ample margin of heat shock resistance, some of which can be sacrificed in making articles that are thicker walled and thus mechanically stronger.

96% silica glasses were developed by Corning in 1939. First, the article is formed from a conventional borosilicate glass. Then a heat treatment causes the glass to separate into two intermingled glassy phases. One phase contains nearly all of the alkalies and can be leached out by hot acids to leave a sponge-like glass containing 96% silica and 3% B_2O_3. The leached glass is so refractory that glass containing subsequent heating can close the pores completely without any change of the shape of the article even though there is a linear shrinkage of about 14%. These glasses can be used at a red heat and plunged into ice water repeatedly without cracking.

Items 212 - 221 are to be answered after reading the above paragraphs and in reference to the following key.

KEY

- **A.** The statement is true and the reason supports the truth of it.
- **B.** The statement is true but the reason does not support the truth of it.
- **C.** The statement is false.

212. (4.2) Glass is a chemical compound because, at a blinding white heat, any two substances react to form a compound.

213. (4.2) At ordinary temperature, glass could be called a solid-liquid because its molecules are scattered about as in liquids.

214. (4.2) In the manufacture of glass, the batch is heated to 2700°F. because 2700°F. is the melting point of silica.

215. (4.2) Lead glass lenses are used in optical instruments because of their high sparkle.

216. (4.2) Borosilicate glasses are used for most heat-resistant glass ware (such as Pyrex ovenware) because they are the only heat-resistant glasses that can be produced by conventional mass production methods.

217. (4.2) Lead glasses are used to make fine tableware and art-glass because they are softer and have higher sparkle than soda-lime glasses.

218. (4.2) Borosilicate glasses are superior to soda-lime glasses in regards to corrosion resistance because boron rusts more easily than the alkalies.

219. (4.2) Fused quartz glasses are often translucent (not transparent) because of the difficulty of removing bubbles from the melt.

220. (4.2) Borosilicate glasses are unstable because they can be separated into two intermingled glassy phases by heat treatment.

221. (4.2) Articles of predetermined size cannot be made from 96% silica glasses because, in their manufacture, there is a linear shrinkage during the final heat treatment.

222. (4.2) If a 96% silica crucible were standing on a cake of ice and molten brass were poured into it, the crucible would most likely (M.P. 940°C.)

A. crack. **B.** melt. **C.** combine with the brass.
D. shrink. **E.** expand.

223. (4.2) When an unknown gas is bubbled through clear lime water, $Ca(OH)_2$, a white precipitate forms. The gas can be assumed to be carbon dioxide providing

- **A.** all of the following are true.
- **B.** no other gas forms a white precipitate in lime water.
- **C.** no other substance gives a white precipitate with CO_2.
- **D.** that the gas does not react chemically with the lime water.
- **E.** there is no marked change in the temperature of the lime water.

Items 224 - 243 refer to the following problem.

A scientist, when confronted with a problem, formulates hypotheses which represent tentative solutions to the problem. He then collects data which may support or disprove his hypotheses. Finally, on the basis of the data and the hypotheses thus tested, he derives a conclusion which constitutes his answer to the problem.

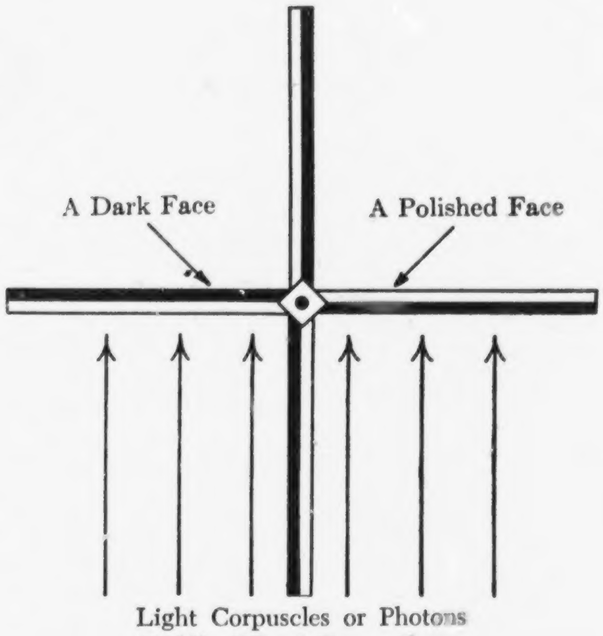
The following exercises represent an effort to test your ability to do scientific thinking. You are to test certain true or false hypotheses, and to evaluate certain general conclusions. Assume that each item of data below each hypothesis is a true statement and may directly or indirectly help to prove an hypothesis true or false. If the application of the item of data requires only one step to prove the truth or falsity of an hypothesis, then the item is a direct help. For example, the temperature of water boiling on a given mountain and at sea level would represent direct evidence of the falsity of the hypothesis "water boils at a higher temperature on a mountain than at sea level."

A number of years ago Sir William Crookes perfected an instrument which always intrigues people, whether laymen or scientists. This is the radiometer, a device consisting essentially of a paddle wheel which is free to rotate in a horizontal plane within a partially evacuated glass bulb. One side of each paddle is brightly polished, while the other side is coated with lampblack. As soon as the device is placed in the sunlight, the little paddle wheel starts to spin rapidly. It continues to spin until the device is again placed in the dark.

PROBLEM: How does sunlight cause the paddle wheel to rotate?

Below are given a series of hypotheses, each of which is followed by numbered items which represent data. After each item number on the answer sheet blacken space

- **A.** if the item directly helps to prove the hypothesis true.
- **B.** if the item indirectly helps to prove the hypothesis true.
- **C.** if the item directly helps to prove the hypothesis false.
- **D.** if the item indirectly helps to prove the hypothesis false.
- **E.** if the item neither directly or indirectly helps to prove the hypothesis true or false.



Paddle Wheel From Above

HYPOTHESIS I: In a partial vacuum the paddle wheel rotates because of the impact of particles, or photons, of light.

224. (4.2) Scientists now believe that light has both corpuscular and wave characteristics.

225. (4.2) In a very high vacuum the bright faces of the paddle wheel turn slowly away from the light, while the black faces turn toward the light.

226. (4.2) Light travels at the rate of 186,000 miles per second.

227. (4.2) In a partial vacuum the black faces of the paddle wheel turn away from the light, while the bright faces turn toward the light.

228. (4.2) After this item number on the answer sheet blacken space A if Hypothesis I is true, or space B if it is false.

HYPOTHESIS II: A paddle wheel on which all of the faces are bright or all black will not rotate.

229. (4.2) Rotation is due to force of impact. If all paddles are the same on both sides, either all bright or all black, the turning forces would cancel.

230. (4.2) More photons rebound from bright faces than from dark faces.

231. (4.2) In a partial vacuum, air molecules are constantly hitting the paddles.

232. (4.2) Photons are hitting the sides of the paddles which face the light.

233. (4.2) After this item number on the answer sheet blacken space A if Hypothesis II is true, or space B if it is false.

HYPOTHESIS III: Rotation in a partial vacuum of the paddle wheel is due to the greater force of rebound of air molecules from the black faces than from the bright ones.

234. (4.2) In a partial vacuum and in the dark the paddle wheel will rotate when exposed to invisible infra-red rays from a warm flatiron.

235. (4.2) The black faces of the paddles become warmer than the bright faces, since they absorb more light.

236. (4.2) Air molecules adjacent to the warmer black faces rebound from these faces with greater energy than from the cooler bright faces.

237. (4.2) In a very high vacuum and in the dark the paddle wheel will rotate slowly if invisible rays from a cathode tube are directed toward it.

238. (4.2) After this item number on the answer sheet, blacken space A if Hypothesis III is true, or space B if it is false.

Below are five conclusions. After corresponding numbers on the answer sheet blacken space

A. if in your judgment the conclusion is the best answer to the problem.

B. if in your judgment the conclusion is neither the best answer nor the least satisfactory answer to the problem. (Three conclusions should receive this mark.)

C. if in your judgment the conclusion is the least satisfactory answer to the problem.

239. (6.1) The paddle wheel of the radiometer rotates, because air molecules move with greater energy when heated by energy from sunlight or from infra-red rays from a flatiron.

240. (6.1) Air molecules rebound with greater force from the bright faces, which reflect more light energy. Photons rebound from dark faces to a greater extent than from bright faces. The turning forces thus created cause black faces to rotate toward the light in a partial vacuum and away from the light in a very high vacuum.

241. (6.1) The paddle wheel of the radiometer rotates; because photons of light strike air molecules with greater energy when adjacent to the dark faces than when adjacent to the bright faces.

242. (6.1) The fact that a radiometer will operate in either a partial or a very high vacuum demonstrates that it is not essential that air molecules be present in order to cause rotation.

243. (6.1) Air molecules rebound with greater force from the black faces, which absorb more light energy than the black faces. Photons rebound from bright faces to a greater extent than from dark faces. The turning forces thus created cause black faces to rotate away from the light in a partial vacuum and toward the light in a very high vacuum.

Items 244 - 245 deleted.

The methods of science have been characterized as "self-rectifying," in the sense that on the basis of assumptions of hypotheses which hold only approximately, scientific investigations can reach results which *correct* the very assumptions on which the investigation was based.

One consequence of the above characterization of scientific methods is that *conclusions reached in scientific research have an important function in guiding further research.*

For each of the following questions use the answer space to write in the letter corresponding to the alternative that best illustrates this "guiding" function of scientific conclusions.

246. (4.2) **A.** The role of changes of velocity in Galileo's theory of falling bodies and Huygens' theory of impact leads Newton to base his science of motion on the conception that force produces a change in the state of motion of a body.

B. Newton's definition for "innate force" as a power by which bodies tend to persist in their states of rest or motion, leads to his statement of the first Law of Motion.

C. Newton's conception of the "accelerative measure of a centripetal force" leads him to investigate the relation between the mass of a body and its weight.

D. Kepler's "Law of Areas" is the basis of Newton's theorem, that a body B urged by a centripetal force to a center A moves so that the radius AB covers equal areas in equal times.

E. Newton's generalization of the theory of impact to include imperfectly elastic bodies leads him to his law of the conservation of momentum.

Answer________________.

247. (4.2) **A.** The conclusion that "force" or energy is conserved in the motions of falling bodies and in elastic impacts leads Leibniz, and later Mayer, to consider the question: What happens to energy in inelastic impacts or in situations involving friction?

B. The conclusion that momentum is conserved only in a system of bodies on which no external forces act leads Leibniz and Mayer to look for some quantity which is always conserved.

C. The law of the conservation of momentum leads Leibniz to the law of the conservation of energy; since the former refers to the product of mass and velocity, the latter to half the product of mass and the square of velocity, each law implies the other.

D. The experimental conclusion that a given loss of mechanical energy always leads to production of the same quantity of heat, forms the basis for Mayer's determination of the mechanical equivalent of heat.

E. The determination of the mechanical equivalent of heat leads Mayer to an appreciation of the importance of numbers in science.

Answer________________.

248. (4.2) **A.** Newton's classification of impressed forces as due to percussion, pressure, or centripetal force is part of the basis of kinetic-molecular investigations of pressure.

B. Newton's principle that "Nature affects not the pomp of superfluous causes" motivates kinetic theory in discarding the conception of caloric, when the motions of molecules are found to be sufficient to account for the pressure of gases.

C. Galileo's conception of the "force of a vacuum" leads to the investigation, by kinetic-molecular theory, of the real source of the resistance to a vacuum, namely pressure.

D. The experimentally determined laws of gases lead kinetic-molecular theory to investigate the relation of the temperature of a gas to the product of its pressure and its volume.

E. The conclusions of Newtonian mechanics, the atomic theory in chemistry, and the principle of the mechanical equivalent of heat provide the foundation for the kinetic-molecular theory.

Answer________________.

249. (4.2) For *one* of the above three questions (246, 247, and 248) state your reasons for preferring the alternative you have chosen over all the others.

250. (4.2) A symbol, if it is to have value as a means of communication between one person or group and another, must possess which one of the following characteristics?

A. It must suggest to the person using it some characteristic of the object or concept that it represents.

B. It must suggest to the person using it as wide a variety of objects or concepts as possible.

C. It must suggest to all persons using it the same object or concept.

D. It must convey the same meaning to all individuals using it, and this meaning must not change from one year or decade to the next.

E. It must first have become traditional and accepted by several generations of people.

251. (4.3) You are to write an essay on the relation between physics and biology. The materials of the spring quarter have been selected to help you to bring your knowledge of the natural sciences to bear upon this problem. The Bernard reading represents a view which can be used as a starting point for your analysis; for the later authors, Bohr, Schrodinger and Delbruck, may be said to agree with Bernard, in that none believes in extra-physical "forces" such as Bernard rejects, while all accept the fact of "organization" in living things.

Your essay should therefore include an analysis of the sense in which physics and chemistry "explain" biology according to Bernard. Since Schrodinger, Delbruck and Bohr agree with Bernard in the sense indicated above, it will be part of your task to make clear what further problems exist for them, and what differences there are among the views presented by the four authors. In this connection, the relevance of changes in physics and biology since Bernard should be considered.

Although the spring quarter readings are to serve as the nucleus of your discussion it is upon the issue represented rather than the particular authors' views that your emphasis should be placed. Therefore, you should be sure to make clear not only the positions of the authors, but the grounds or reasons for these positions, and the nature of the evidence which might suffice to decide the issue.

Write your essay in the special essay booklet.

2. *History of Science*

HISTORY OF SCIENCE

1. (1.1) The general climate of thought in the early days of the Christian era was unfavorable for the growth of science because

A. it was felt that the Greeks had already discovered everything of any importance.
B. it was felt that a knowledge of literature and art was more important than a knowledge of science.
C. the Second Coming of Christ, which was expected to occur shortly, would mark the end of the world and of all secular knowledge.
D. everyone had everything necessary for a happy peaceful life.
E. it was felt that the writing of the Bible was the only task worthy of consideration.

2. (1.1) The period in history between 450 and 1150 A.D. is often referred to as the Dark Ages. This period was characterized by

A. a conflict of philosophies between scientists.
B. a conflict between the Church and science.
C. widespread abstract science with no practical application.
D. no scientific activity whatsoever.
E. intense scientific activity.

True or False.

3. (1.1) Newton and Galileo were laboratory partners.

4. (1.1) The most probable reason that the early Egyptians made little attempt to study the weather was that

A. it was considered sacrilegious.
B. the weather varied but little from season to season.
C. agriculture was more or less independent of the weather.
D. they lacked the necessary mathematical tools.
E. all of the above are equally probable.

5. (1.1) Our present concept of the relative movements of the planets is usually accredited to

A. Galileo. **B.** Ptolemy. **C.** Copernicus.
D. Tycho Brahe. **E.** Newton.

6. (1.1) The name oxygen means

A. heat-producer. **B.** acid-former.
C. neutralizer. **D.** base-former.
E. weight-increaser.

Items 7 - 13 refer to the knowledge which is usually associated with certain men. For each item select the most appropriate response.

KEY

A. Copernicus. **B.** Galileo. **C.** Kepler.
D. Ptolemy. **E.** Tycho Brahe.

7. (1.1) In appropriate units of measurement, the square of the period of revolution of a planet is equal to the cube of its distance from the sun.

8. (1.1) Observation of sun spots convinced him that the sun rotates.

9. (1.1) A planet moves in a small circle called an epicycle around a point which moves in the orbit of the planet around the earth.

10. (1.1) His accurate observations were of great value to another astronomer in the list.

11. (1.1) The astronomer who suggested the most radical departure from the views held by other astronomers before his time.

12. (1.1) The astronomer who proposed that the planets revolve around the sun in circular orbits.

13. (1.1) The astronomer to whom we owe the concept that the distance from the earth to the sun varies during the year.

14. (1.1) Marie Curie was

A. a Polish woman living in Paris.
B. an Italian living in Rome.
C. a French woman living in New York.
D. an Italian living in New York.
E. a French woman living in Paris.

15. (1.1) Chemistry developed from

A. alchemy. **B.** astrology. **C.** astronomy.
D. photochemy. **E.** anthropology.

Human history can be subdivided into various periods such as the five periods below

A. Before the death of Aristotle (322 B.C.).
B. From 322 B.C. to the death of Copernicus (1543).
C. From 1543 to the death of Galileo (1642).
D. From 1642 to the death of Lavoisier (1794).
E. From 1794 to the present.

Twelve important scientific events or ideas are given below. By your knowledge of the evolution of the scientific developments rather than by memory of dates, indicate to which of the above five periods each of these events or ideas belongs, by blackening the appropriate space on the answer sheet.

16. (1.22) First proposal of an atomic theory of matter.

17. (1.22) Controversy over Avogadro's hypothesis.

18. (1.22) First use of the telescope in astronomy.

19. (1.22) Phlogiston theory of combustion flourished.

20. (1.22) Proposal of the theory of universal gravitation.

21. (1.22) Establishment of the law of conservation of energy.

22. (1.22) Ptolemy's geocentric hypothesis of celestial bodies widely accepted.

23. (1.22) Tycho Brahe's observations of Mars.

24. (1.22) Brownian motion first correctly explained.

25. (1.22) First proposal that the earth was spherical.

26. (1.22) Discovery of oxygen.

27. Mendeleef's prediction of new elements.
(1.22)

For items 28 and 29 select from the key the scientist most closely related with the field of endeavor.

KEY

A. Faraday. **B.** Hertz. **C.** Lavoisier.
D. Mendeleef. **E.** Tycho Brahe.

28. Combustion.
(1.1)

29. Electromagnetic radiation.
(1.1)

30. The reason that an incorrect theory, such as the *Fluid*
(1.24) *Theory of Electricity* could have survived and been accepted for so long was that

A. in its day it constituted a distinct step forward.
B. it was useful in advancing scientific knowledge.
C. it provided a pattern into which a mass of otherwise unrelated phenomena could be fitted.
D. all of the above items are correct.
E. none of the above items is correct.

31. Prior to the modern atomic theory and some studies in
(1.1) radioactivity, the scientist who proposed the first really valuable atomic theory, which served as a good working hypothesis without any absolute proof of its correctness for about a century, was

A. Robert Boyle. **B.** John Dalton.
C. Ernest Rutherford. **D.** Benjamin Franklin.
E. Albert Einstein.

32. Our present concept of the relative movements of the
(1.1) planets of the solar system is generally credited to

A. Kepler. **B.** Ptolemy. **C.** Copernicus.
D. Tycho Brahe. **E.** Galileo.

33. Oxygen was discovered
(1.1)

A. approximately 100 B.C.
B. approximately 500 A.D.
C. about the time Columbus discovered America.
D. about the time of the Declaration of Independence.
E. just before our Civil War.

For items 34 - 38 select from the key the field of endeavor most closely related to the widely known present-day scientist.

KEY

A. Astronomy. **B.** Geology. **C.** Chemistry.
D. Physics.

34. J. R. Oppenheimer.
(1.1)

35. Arthur H. Compton.
(1.1)

36. Harlow Shapley.
(1.1)

37. R. A. Daly.
(1.1)

38. Irving Langmuir.
(1.1)

For items 39 - 43 select from the key the scientist most closely related with the field of endeavor.

KEY

A. Mendeleef. **B.** Lavoisier. **C.** Tycho Brahe.
D. Hertz. **E.** Faraday.

39. Combustion.
(1.1)

40. Electromagnetic radiation.
(1.1)

41. Periodic chart.
(1.1)

42. Static electricity.
(1.1)

43. Astronomy.
(1.1)

Items 44 - 46 refer to astronomy. For each item select the name which is associated with the statement.

KEY

A. Ptolemy. **B.** Galileo. **C.** Kepler.
D. Copernicus. **E.** Tycho Brahe.

44. His use of the telescope showed that the sun rotates.
(1.1)

45. His beliefs included that all parts of the solar system
(1.1) move about a stationary earth.

46. He formulated the most important mathematical laws
(1.1) concerning the solar system.

47. After the early pioneers of science, 600 B.C. to 150 A.D.,
(1.1) the rebirth and revival of science took place

A. about the time of Ptolemy.
B. about 600 A.D.
C. when Newton stated his Laws of Motion.
D. about 1500 A.D., the time of Galileo.
E. about 1800, the time of Joule and Coulomb.

Items 48 - 50 refer to some of the early pioneers in science. Select from the key the name to be associated with each accomplishment.

KEY

A. Thales. **B.** Euclid. **C.** Archimedes.
D. Hipparchus. **E.** Aristotle.

48. The first great experimentalist.
(1.1)

49. Started the science of mathematics.
(1.1)

50. Influenced man's general culture more than any other
(1.1) man.

51. The contribution of the Universal Law of Gravitation
(1.1) was made by

A. Copernicus. **B.** Galileo. **C.** Kepler.
D. Ptolemy. **E.** none of the above.

52. All parts of the solar system move around a stationary
(1.1) earth. This theory was supported by

A. Ptolemy. **B.** Galileo. **C.** Kepler.
D. Copernicus. **E.** Tycho Brahe.

53. What evidence that the earth revolves about the sun
(1.1) was not available to Tycho Brahe or to Galileo, although both recognized the significance of such evidence?

A. Observation of the phases of Venus.
B. The transit of Venus across the sun's disk.
C. Revolution of the satellites of Jupiter.
D. Fluctuations of the Cepheid variables.
E. Annual parallactic displacement of stars.

54. In Babylonia and Egypt, the *main* interest in astronomy
(1.1) was to

A. explain the apparent motion of the sun and the planets.

B. maintain a calendar.
C. predict eclipses of the sun and the moon.
D. devise a geometric system of the universe.
E. attain knowledge mainly for the satisfaction of knowing.

55. (1.1) The chief contribution of Claudius Ptolemy to the science of astronomy was that he

A. proposed that the universe consisted of 55 crystal spheres.
B. discovered the precession of the equinoxes.
C. calculated the distance to the sun and the moon.
D. introduced the concept of epicycles to better explain the planetary motions.
E. compiled all known astronomical data.

56. (1.1) Earthquakes, occurring at a rate exceeding 1000 per day in the earth, were explained by the Greek and Roman philosophers as due to

A. deformations of the earth's crust.
B. compressional forces accompanying the cooling of the earth.
C. violent movements of winds that had been imprisoned within the earth.
D. seismic sea waves.
E. lunar tidal forces.

57. (1.1) The most feasible explanation of the lack of major discoveries regarding the universe during the first fourteen centuries of the Christian era involves

A. the failure of anyone to have developed the scientific method.
B. the failure to have rediscovered the works of Aristotle, Plato, etc.
C. the tendency to rely on reasoning from authority rather than from observation.
D. the lack of instruments permitting accurate observation of celestial mechanics.
E. any of the above: all are equally probable.

58. (1.1) One of the outstanding aspects of Greek science from 600-200 B.C. was

A. the tendency to rely on reasoning from authority.
B. the search for knowledge for the satisfaction of knowing.
C. the belief in and practice of astrology.
D. the belief that secular knowledge was subordinate to sacred knowledge.
E. none of the above.

59. (1.1) The search for the planetoids and the planet Uranus was motivated by

A. Newton's Law of Universal Gravitation.
B. perturbations in the motion of the planet, Saturn.
C. Bode's Law. **D.** Kepler's Third Law.
E. the development of photographic astronomy.

60. (1.1) In a magneto the magnetic field is supplied by

A. permanent magnets.
B. electromagnets fed by direct current.
C. electromagnets fed by alternating currents.

61. (1.1) Electromagnetism was discovered by

A. Volta. **B.** Harvey. **C.** Faraday. **D.** Oersted.

62. (1.1) The first recorded experimental study of the earth's magnetism was made by

A. Thales. **B.** Gilbert. **C.** Peregrinus. **D.** Hudson.

Items 63 - 77.

The following list contains the names of several persons who have made significant contributions to the advancement of human thought. In the space before each name, write

A if the person lived before A.D. 1.
B if he lived between A.D. 1 and A.D. 400.
C if he lived between A.D. 400 and A.D. 1400.
D if he lived between A.D. 1400 and A.D. 1750.
E if he lived after A.D. 1750.

63. (1.1) ______ Ptolemy.
64. (1.1) ______ Democritus.
65. (1.1) ______ Galileo.
66. (1.1) ______ Aristarchus.
67. (1.1) ______ Plato.
68. (1.1) ______ Kepler.
69. (1.1) ______ Eratesthenes.
70. (1.1) ______ Hipparchus.
71. (1.1) ______ Euclid.
72. (1.1) ______ Aristotle.
73. (1.1) ______ Archimedes.
74. (1.1) ______ Newton.
75. (1.1) ______ Copernicus.
76. (1.1) ______ Pythagoras.
77. (1.1) ______ Thomas Aquinas.

Items 78 - 92 list achievements of some of the persons named in items 63 - 77. Place the number of each person before the achievement for which he is known.

78. (1.1) ______ Invented the first practical telescope.

79. (1.1) ______ First measured the circumference of the earth.

80. (1.1) ______ Systematized all the geometry known up to his time.

81. (1.1) ______ Proposed the modern heliocentric theory.

82. (1.1) ______ Believed in the heliocentric theory on philosophical grounds.

83. (1.1) ______ Showed that the orbits of the planets are not circles but ellipses.

84. (1.1) ______ Discovered the law of the lever.

85. (1.1) ______ Compiled an encyclopedia of astronomy embodying the geocentric theory.

86. (1.1) ______ Formulated the principles of logical reasoning.

87. (1.1) ______ Developed the concept of density or specific gravity.

88. (1.1) ______ The greatest experimenter (in physical science) of antiquity.

89. ______ Reconciled the ideas of the ancients with the
(1.1) dogmas of the church.

90. ______ Wrote many books on physical science which
(1.1) were accepted as authoritative by the mediaeval church, in spite of their many errors.

91. ______ Originated a very early atomic theory.
(1.1)

92. ______ Showed that all motion, on earth or in the
(1.1) heavens, was governed by the same great general law—the law of gravitation.

Items 93 - 101. In the space before each item, write the letter(s) preceding the term(s) in the column at the right which correspond(s) to it.

A. Induction.
B. Deduction.
C. Objectivity.
D. Subjectivity.
E. Hypothesis.
F. Theory.
G. Law.

93. ______ A guess which has not been subjected to the
(1.1) test of experiment.

94. ______ The reasoning process which is used when one
(1.23) concludes that yttrium must be the name of a metal when one knows that the names of metals commonly end in -ium.

95. ______ When two persons, reasoning from the same
(1.25) data, arrive at differing conclusions, their thought processes must have . . .

96. ______ The reasoning process involved in the following:
(1.23) measure the circumference of a plate, a saucer, a round table; measure their diameters; divide the first by the second in each case: conclusion—the ratio of the circumference of any circle to its diameter is 3.14.

97. ______ Measurement is a means of obtaining . . .
(2.1)

98. ______ Of the last three terms in the column, which
(1.3) may have to be altered or rejected because of the discovery of additional data?

99. ______ Which is most likely to be rejected or to need
(1.1) modification?

100. ______ A guess which has been thoroughly tested ex-
(1.1) perimentally and which agrees with all known facts.

101. ______ Even though it may later be proved to be wrong,
(1.1) it may be useful because it suggests new experiments.

102. The earliest speculations regarding the geological aspects
(1.1) of the earth were concerned largely with events relating to the phenomena of

A. streams and valleys. **B.** metals and minerals.
C. wind erosion and dunes.
D. floods and stream deposits.
E. volcanoes and earthquakes.

103. "An increase of pressure on any part of a confined liquid
(1.1) causes an equal increase of pressure throughout the liquid" is a statement contributed by

A. Archimedes. **B.** Charles. **C.** Bernoulli.
D. Pascal. **E.** Dalton.

104. The failure of the Romans to make any outstanding
(1.1) contributions to science was because they were

A. poor engineers. **B.** good soldiers and lawyers.
C. little interested in practical applications of science.
D. uninterested in abstract speculation and reasoning.
E. unable to understand most of the writings of the Greek philosophers.

105. The concept of Scholasticism included all of the follow-
(1.3) ing *except*

A. all secular knowledge was subordinate to sacred knowledge and must contribute to its support.
B. belief in the power of reason and logic.
C. belief in the power of faith.
D. acceptance of the writings of Aristotle, Plato, and Ptolemy as part of the theology of the Church.
E. antagonism to the development of experimental science.

106. One belief of the Scholastics was eventually to become
(1.3) one of the basic assumptions of scientists everywhere. This was the belief that

A. all of nature and the universe is one orderly, rational unit.
B. the past history of the universe is revealed only in the Bible.
C. if an authority says a thing is so, it must be so, and there is no need to investigate further.
D. deductive reasoning from accepted authorities is the one sure way to discover the truth.
E. the will is more powerful than the intellect.

107. The attitude of the Scholastics with regard to science is
(2.1) best indicated by which one of the following?

A. Science is the most important field of human knowledge.
B. All secular knowledge including science is of less importance than theology and must support the teachings of the Church.
C. There is no conflict between the writings of the Greek philosophers and the Fathers of the Church.
D. Why things happen is less important than how they happen.
E. Faith and revelation may contradict science.

3. Cosmogony—
Sun, Stars, and Nebulae

COSMOGONY—SUN, STARS, AND NEBULAE

1. (1.1) Interpretation of stellar spectra cannot give information about a star's

A. surface temperature. **B.** chemical content.
C. density. **D.** motion toward the earth.
E. motion away from the earth.

2. (1.1) Which one of the following is *not* true of the sun?

A. It is a star. **B.** It rotates.
C. It belongs to the Milky Way Galaxy.
D. It is hotter than any known star.
E. It has a tidal effect on the earth.

3. (1.1) The continued generation of energy in the sun involves the combination of hydrogen atoms to form helium atoms. This reaction furnishes a large amount of energy because it is

A. an ordinary chemical reaction.
B. an example of natural radioactive disintegration.
C. the same reaction that is used in an atomic bomb.
D. a reaction in which a considerable quantity of matter is converted to energy.
E. a combustion reaction in which a large quantity of matter is burned up.

4. (1.1) An absorption spectrum is capable of yielding information about the composition of the atmospheres of stars because

A. the more dense the absorbing material, the greater is the absorption.
B. atoms absorb the same frequencies which they are able to emit.
C. the position of absorption bands indicates the temperature of the star.
D. the intensity of the absorption bands indicate which elements are present.
E. the stellar atmospheres reduce the intensity of the glare from the stars.

5. (1.1) The rate of rotation of the sun can be determined from

A. a continuous record of the quantity of solar radiation received at the earth's surface during the year.
B. observations of the variations in the apparent size of the sun during the year.
C. measurements of the intensities of the absorption bands in the solar spectrum.
D. a comparison of the spectra received from the western and eastern edges of the sun.
E. none of the above.

For items 6 - 9, identify the parts of the sun as given in the key with their descriptions given in the items.

KEY

A. Photosphere. **B.** Reversing layer.
C. Chromosphere. **D.** Corona. **E.** Prominences.

6. (1.1) The more rarefied atmosphere of the sun ordinarily visible as a diffuse halo during a total eclipse.

7. (1.1) That part of the sun which radiates most of the solar energy.

8. (1.1) That part of the sun where the majority of the absorption lines have their origin.

9. (1.1) The layer where occur the vast disturbances responsible for sun spots and prominences.

10. (1.1) Which one of these statements concerning astronomical space and measurements in space is false?

A. Astronomical space is mostly empty.
B. The astronomical unit is the distance from the earth to the pole star.
C. a parsec is a unit for measuring vast distances.
D. The apparent brightness of stars is expressed as star magnitude.
E. A light year equals 186,000 mi./sec. times 365 days times 24 hrs. times 3600 sec.

11. (1.1) The velocity of a star toward or away from the earth can be detected by

A. photographing it at two different times.
B. determining its right ascension at intervals of a year.
C. measuring variations in the angle of parallax.
D. measuring the diameter of the star from time to time.
E. comparing its spectra with spectra obtained in the laboratory.

12. (1.1) The latitude of city X is 42.5° N. An observer in city X notes that a star has a constant altitude of 42.5°. The star is

A. Proxima Centauri. **B.** Polaris. **C.** Vega.
D. Sirius. **E.** The sun.

13. (1.1) The annual parallactic displacement of any nearby star supports the hypothesis that the

A. star is a double one.
B. axis of the earth is inclined.
C. earth revolves about the sun.
D. star is really a planet.
E. earth is an oblate spheroid.

14. (1.1) The presence or absence of certain elements in a star is generally determined from

A. the velocity of light from the star.
B. the temperature of the star.
C. the dark and bright line spectra.
D. a sample of the star (e.g., a meteorite from the particular star).
E. a different type of information than listed here.

15. (1.1) Apparent changes in the wave length of light from beyond the solar system are caused by

A. interference. **B.** refraction of layers of air.
C. reflection. **D.** the Doppler effect.
E. diffraction effects.

16. (1.1) A planet can be distinguished from a star, even by naked-eye observation, because

A. all the planets appear larger than any star.
B. the planets are much closer to the earth.
C. the planets are members of the solar system.
D. a star appears to twinkle, a planet does not.
E. the light from the stars appears to be bluer than that from the planet.

17. (1.1) The most important device of the following for gathering data concerning the stars is the

A. mirror. **B.** thermocouple. **C.** pendulum.
D. electroscope. **E.** magnet.

Item 18 deleted.

19. (1.1) Which one of these is the largest quantity?

A. The light year.
B. The Parsec (19,000,000,000,000 miles).
C. 7,280 Angstrom units.
D. The distance to the nearest star beyond the sun.
E. The astronomical unit (mean radius of the earth's orbit).

20. (1.1) Stars, as seen by the eye, vary in color *largely* because of

A. difference in composition.
B. temperature differences.
C. parallax effects when viewing objects at great distances.
D. the Doppler effect. **E.** differences in size.

21. (1.1) Which of the following is *not* true? The spectrum of a star can be utilized to

A. determine whether it is approaching towards or receding from the earth.
B. estimate its temperature.
C. analyze its component elements.
D. determine the frequency of the maximum radiation emitted.
E. determine what chemical changes are responsible for its glow.

22. (1.1) Fraunhofer lines in the sun's spectrum represent

A. the results of sympathetic vibration.
B. evidence that the sun is an incandescent solid.
C. evidence that elements exist on the earth that are not found on the sun.
D. evidence that elements exist on the sun that are not found on the earth.
E. the results from molecular rather than atomic excitation.

23. (1.1) How can the distance to one of the nearest stars be determined?

A. By measurement of the angle subtended to two distant points of observation on the earth's surface.
B. By measurement of the shift of the star, when observed from the same station at two different times of the year.
C. By measurement of the amount of the brightness of the star.
D. By measurement of the time required for light to travel from the star to the earth.

24. (1.1) Which one of these is the smallest quantity?

A. The astronomical unit (mean radius of the earth's orbit).
B. The distance to the nearest star outside of the solar system.
C. 5.88 x 10^{12} miles.
D. The parsec (19,000,000,000,000 miles).
E. The light year.

25. (1.1) Data on the universe in space is associated with all of these *except*

A. dark line spectra. **B.** isostacy.
C. the Doppler effect. **D.** spectroscopic photographs.
E. the red shift of the spectrum.

For items 26 - 28 select from the key the measurement most related to the statement.

A. Astronomical unit. **B.** Parsec.
C. Fraunhofer lines. **D.** Light year.
E. Radiometric unit.

26. (1.1) Useful in determining the composition of stars.

27. (1.1) This unit becomes too unwieldy to be of value in determining and expressing stellar distances.

28. (1.1) Defined as the mean radius of the earth's orbit.

29. (1.1) The star that has the highest temperature among a group of stars is the one whose light appears

A. red. **B.** yellow. **C.** blue. **D.** white.
E. black.

30. (1.1) One who makes accurate measurements of celestial bodies is called a/an

A. mind-reader. **B.** astrologer. **C.** fortune-teller.
D. astronomer. **E.** soothsayer.

31. (1.1) Which one of these is *least* useful in determining the physical characteristics of a star?

A. Telescope. **B.** Spectroscope. **C.** Camera.
D. Spectrograph. **E.** Electroscope.

Items 32 - 35 refer to various groups of names or terms used in physical science among which comparisons are frequently made. For each item select from the key the most appropriate response.

KEY

A. C, A, B. **B.** B, C, A. **C.** A, B, C.
D. C, B, A. **D.** Some other order.

32. (1.1) The following list of astronomical objects vary greatly in size or massiveness:

A. Comet. **B.** Spiral. **C.** Sun.
Select the correct order of increasing massiveness from the key.

33. (1.1) Select from the key the correct order of increasing temperatures for the following list of celestial objects.

A. A Blue Star. **B.** A Red Star. **C.** The Sun.

34. (1.1) Select from the key the correct order of increasing atomic weights of the following heavy elements.

A. Gold. **B.** Lead. **C.** Uranium.

35. (1.1) Select from the key the correct order of decreasing age (from oldest to youngest) of the following geologic events.

A. The Appalachian Revolution.
B. The End of Glaciation in Michigan.
C. The Formation of the Rocky Mountains.

36. (1.22) The stars are not all at the same distance from the earth. Which of the following is the best observational evidence for this statement?

A. Some stars are red; others are blue.
B. Their annual shifts in positions are not alike.
C. Space is three-dimensional.
D. Some stars are brighter than others.
E. The relative positions of the stars vary slowly throughout the centuries.

37. (1.3) After reading the following sentence which statement would a scientist most probably choose to agree with? "When the sun passes again near another sun, the planets will be broken up and destroyed, and their remains will be scattered along the arms of a new spiral nebula, in time becoming parts of a new family of planets."

- **A.** The statement is based on an hypothesis that has been proved to be erroneous.
- **B.** The statement is based on a theory that has been proved sufficiently to achieve the status of a law.
- **C.** The statement is based on the illogical assumption that there can be more than one sun.
- **D.** The statement gains credence from the fact that meteorites bear evidence of having been parts of planets.
- **E.** The statement agrees with the currently most widely accepted theory of the formation of the earth.

38. (1.3) Which one of the following is most useful in determining the relative motion of the stars?

A. Lenz' Law. **B.** Kepler's Law.
C. Doppler Effect. **D.** Photoelectric Effect.
E. Radioactivity.

Items 39 - 41 are based on this situation involving the sun and two other equal-sized stars x and y. Stars x and y are approximately the same distance from the earth. Star x is a red star. Star y is a blue star. The sun is a yellow star with a surface temperature of about 6000°A

39. (2.1) The surface temperature of star x is

A. greater than 6000°A. **B.** same as 6000°A.
C. less than 6000°A. **D.** not determined by the data.

40. (2.1) Each square centimeter of star x radiates per second

- **A.** more energy than a sq. cm. of star y.
- **B.** less energy than a sq. cm. of star y.
- **C.** the same quantity of energy as star y.
- **D** an indeterminate quantity of energy (in relation to that of a sq. cm. of star y)

41. (2.1) Star x will appear

- **A.** brighter than star y.
- **B.** of same brightness as star y.
- **C.** of less brightness than star y.
- **D.** of an indeterminate-brightness (in relation to that of star y).

42. (2.3) If the tail of a comet struck the earth, which of the following would most likely occur?

- **A.** Nothing.
- **B.** A shower of meteors would strike the earth.
- **C.** Gases would poison our atmosphere.
- **D.** The tail would burn in air.
- **E.** The sun would be obscured.

Items 43 - 46 are based on the following three facts which have been observed to be true regarding a certain star:

1. The star is red in color.
2. It has a parallax (difference in apparent direction) measurable by direct observation.
3. The spectrum of the star shows all parts of its spectrum shifted toward the red.

Select from the key the most appropriate statement.

KEY

- **A.** Based on evidence (1) the statement is *true*.
- **B.** Based on evidence (2) the statement is *true*.
- **C.** Based on evidence (3) the statement is *true*.
- **D.** Based on evidence (1), (2), or (3) the statement is *false*.
- **E.** No evidence is given in (1), (2), *or* (3) by which the statement may be judged.

43. (2.4) The star is relatively close to the earth (compared with other stars).

44. (2.4) The star is rotating on its axis at a relatively rapid rate (for comparison, much more rapidly than the earth).

45. (2.4) The star is approaching the earth.

46. (2.4) The star, compared with most other stars, is relatively cool.

47. (4.1) It is postulated in the Hoyle-Lyttleton Theory that the expansion of the Universe is caused by pressure which results from the continuous creation of hydrogen in space. The continuous creation of hydrogen in space is

- **A.** a contradiction to the Biblical account of Creation.
- **B.** impossible according to current atomic nuclear theory.
- **C.** impossible because matter cannot be created.
- **D.** impossible because sufficient energy is not available.
- **E.** an hypothesis.

48. (6.2) The best evidence that meteors may be the remains of comets is the fact that

- **A.** little damage is done when they strike the earth.
- **B.** many of them are composed of nickel and iron.
- **C.** their light comes from their combustion rather than from the sun.
- **D.** their density approximates that of the nucleus of a comet.
- **E.** many of them travel in groups whose orbits resemble those of comets, some of which no longer reappear.

4. *Solar System—Nature and Theories of its Origin*

SOLAR SYSTEM—NATURE AND THEORIES OF ITS ORIGIN

1. (1.1) Proponents of the geocentric theory failed to establish even a partially plausible explanation of

A. stellar parallax.
B. apparent rising and setting of the sun.
C. apparent lack of motion of the Pole star.
D. apparent retrograde motion of the planets.
E. the phase of the moon.

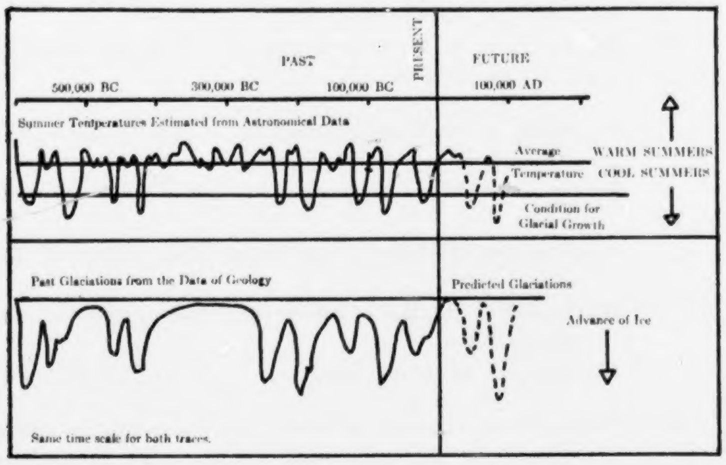
2. (1.1) Which one of these is *not* associated with time of day as commonly employed on earth?

A. The mean solar day. **B.** The prime meridian.
C. 15° of longitude.
D. Two successive crossings of a celestial meridian by the sun.
E. Parallels of latitude.

Items 3 - 11 are to be answered with reference to this selection from "Origin of the Ice," by George Gamow. *Scientific American,* October, 1948.

There are three factors responsible for cool summers: 1) precession of the equinoxes; 2) decreasing eccentricity of the earth's orbit due to the gravitational pull of other planets; 3) straightening of the earth's axis under the gravitational pull of other planets. When all three factors act in the same direction we would expect exceptionally cool summers and the exceptionally fast growth and advance of ice sheets.

Putting together all the existing calculations of the long-range changes in the earth's motion during the past 500,000 years, a Yugoslav geophysicist named Milankovitch, constructed a curve showing the amount of solar heat which was radiated during the summer months upon the Northern and Southern Hemispheres in the course of each geological epoch. In the accompanying chart, this curve for the northern hemisphere, calculated entirely on the basis of astronomical data, is compared with another curve that represents the successive advances of the glacial ice sheets, as they have been estimated by geological studies. The agreement between both curves is striking, and proves beyond any doubt that the glaciations of the past were due to the variations in the earth's orbit caused by the disturbing gravitational pull of other planets.



Note: The earth, in addition to its rotation, or spinning on its axis, and its revolution, undergoes a slow movement known as precession. This movement is somewhat like that of a rapidly spinning top which slowly gyrates, but which always keeps the same angle between its axis and the floor. The earth moves similarly, keeping the same angle of inclination, so that the plane of the celestial equator, which, of course, shifts with the earth, still makes an angle of 23.5° with the plane of the ecliptic. But their points of intersection, or equinoxes, move. This movement of the equinoxes is known as the precession of the equinoxes.

3. (1.1) Precession of the equinoxes was discovered by

A. Ptolemy. **B.** Aristotle. **C.** Hipparchus.
D. Aristarchus. **E.** Galileo.

4. (1.1) The elliptical nature of planetary orbits was discovered by

A. Kepler. **B.** Copernicus. **C.** Galileo.
D. Ptolemy. **E.** Aristotle.

5. (2.1) Straightening of the earth's axis involves

A. removing the kinks from the earth's axis in the interior of the earth.
B. increasing the angle between the earth's axis and the plane of its orbit.
C. decreasing the angle between the earth's axis and the plane of its orbit.
D. changing the direction of the earth's axis so that it points toward the sun.
E. increasing the angle between the ecliptic and the celestial equator.

6. (1.1) Precession of the equinoxes is a result of

A. rotation of the earth on its axis.
B. revolution of the earth in its orbit.
C. oblate spheroid shape of the earth.
D. gravitational attraction of the sun and moon.
E. all of the above

7. (2.3) The period of precession for the earth is approximately 26,000 years which is the basis for the prediction that in the year 15,000 A.D. the earth will have

A. an extended period of glaciation.
B. cooler summers than we have at present.
C. warmer winters than we have at present.
D. colder winters in the northern hemisphere than in the southern hemisphere.
E. cooler summers in the northern hemisphere than in the southern hemisphere.

8. (2.3) It can be predicted that the climate in Michigan 20,000 years from now will be

A. the same as it is now.
B. similar to the present climate of Northern Canada.
C. similar to the present climate of the Southern United States.
D. similar to the present climate of the Arctic.
E. similar to the present climate of the Tropics.

9. (2.3) The almost exact correlation between the trace of summer temperatures and that of past glaciations is probably

A. a true record of historical events.
B. the result of incorrect assumptions.
C. due to completely unrelated phenomena.
D. somewhat fortuitous. **E.** of no importance.

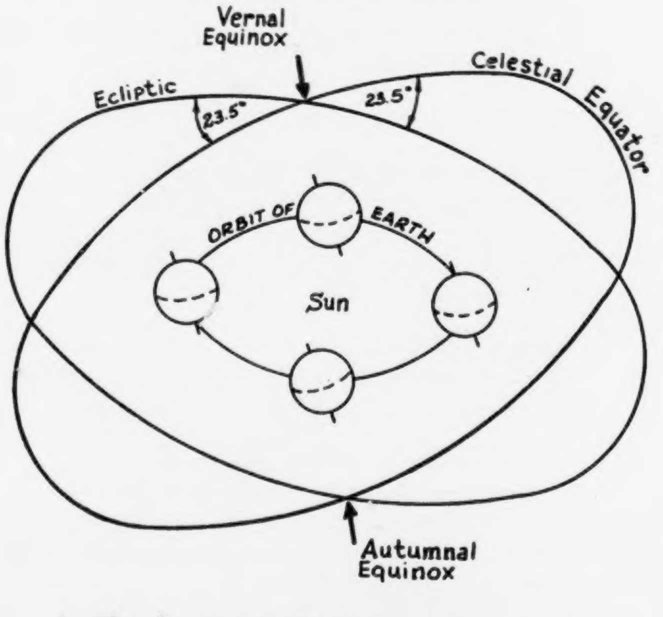
10. (2.3) On the average, the total annual income of solar heat remains the same in all periods. As a result, warm winters accompany cool summers. Warm winters and cool summers are especially favorable for glaciation because

A. approximately the same amount of ice and snow accumulates in warm winters as in cold winters but less of it melts in cool summers than in warm summers.
B. ice and snow do not melt in cool summers.
C. ice and snow accumulate in the cool summers as well as in the accompanying winters.
D. The statement is incorrect. Cold winters are necessary for glaciation.

11. (2.3) The last sentence in the article is

A. true without a question.
B. a statement at variance with observed facts.
C. a statement based on illogical assumptions.
D. probably true.
E. incorrect because this correlation cannot be proved beyond any doubt.

12. (2.1) In the diagram, the vernal equinox is shown near the position of the earth on Sept. 23 and the autumnal equinox is shown near the position of the earth on March 21. How do you explain this?



A. The diagram is incorrect.
B. To an observer on the earth the sun appears to be at these points on the celestial sphere.
C. It is correct to label these points by either term since it is autumn in the southern hemisphere when it is spring in the northern hemisphere and vice versa.
D. The drawing is not drawn according to scale and, hence, the position of the labels does not matter.

13. (1.1) On March 21 there are twelve hours of daylight and twelve hours of night

A. only at the North Pole.
B. only at 66.5°S. latitude. **C.** only at the equator.
D. only at 23.5°S. latitude. **E.** everywhere on earth.

14. (1.1) On December 21st an observer gets a momentary glimpse of the sun on his horizon. This observer is located at

A. the North Pole. **B.** 66.5°N. latitude.
C. 23.5°N. latitude. **D.** 66.5°S. latitude.
E. the South Pole.

15. (1.1) Which one of the following is always along the horizon for all observers on the earth?

A. Celestial equator. **B.** Nadir. **C.** Ecliptic.
D. Meridian. **E.** Azimuth.

16. (1.1) At noon on June 21, the altitude of the sun is 90° for an observer

A. on the equator. **B.** at 23.5°N. latitude.
C. at 66.5°N. latitude. **D.** at 23.5°S. latitude.
E. anywhere on earth.

17. (2.1) An observer in Missouri notes that the North Star is 40° above the horizon. The observer's latitude is

A. 50°N. **B.** 40°N. **C.** 0°N. **D.** 5°N.
E. indeterminate.

18. (1.1) The true solar day is defined as

A. the interval of time between two successive passages of the sun's center across the same meridian.
B. two successive passages of the same star across the same meridian.
C. the average of all the sidereal days in the year.
D. the average of all the solar days in the year.
E. the average of a solar and a sidereal day.

19. (1.1) If a ship traveling westward arrives at the International Date Line at 9:00 P.M. on October 5, what is the time and date immediately on the other side of the line?

A. 9:00 P.M. on October 5.
B. 9:00 P.M. on October 6.
C. 9:00 P.M. on October 4.
D. 9:00 A.M. on October 5.
E. 10:00 P.M. on October 6.

20. (1.1) Observation of irregularities in the orbit of Uranus led to the discovery of Neptune. The calculations were based on

A. data carefully collected by Tycho Brahe.
B. Kepler's Law of Areas.
C. the Law of Gravitation.
D. Newton's First Law of Motion.
E. the Law of the Independence of Motions.

21. (3) When Mars is in conjunction, its distance from the earth is equal to the

A. radius of Mars' orbit minus the radius of the earth's orbit.
B. radius of Mars' orbit plus the radius of the earth's orbit.
C. diameter of Mars' orbit minus the radius of the earth's orbit.
D. diameter of Mars' orbit plus the radius of the earth's orbit.
E. diameter of Mars' orbit.

22. (1.1) Venus shows changes in phase like those of the moon. Observational evidence of this and reasoning by analogy were used to support the hypothesis that

A. the sun and planets revolve about the earth.
B. Venus rotates on its axis.
C. the planets including the earth revolve about the sun.
C. the orbits of the planets are elliptical.
D. Mars revolves in an elliptical orbit.
E. Mars has an eccentric orbit.

23. (2.2) The planet Jupiter is very oblate. Its polar diameter is about one-fifteenth less than its equatorial diameter. One should suspect from this that Jupiter

A. rotates rapidly on its axis. **B.** has several satellites.
C. has a relatively high orbital speed.
D. is much larger than the earth.
E. has an elliptical orbit.

24. (1.1) In 1582 the date of the vernal equinox had shifted from March 21 to March 11. Pope Gregory decreed a correction of 10 days and a revision of the calendar with respect to leap year. This was necessary because

A. the length of the year had been in error to a large degree.
B. Julius and Augustus Caesar had altered the number of days in certain months.
C. the months do not all have the same number of days.
D. of the cumulative error of the old calendars over a long period of time.
E. of increasingly accurate measurements of the length of the solar day.

25. (1.1) A device that is useful in proving that the earth rotates is a/an

A. barometer. **B.** compass needle.
C. Foucault pendulum. **D.** interferometer.
E. spectrograph.

26. (1.1) Which of these is correct?

A. The earth has the shortest year of all the planets.
B. Jupiter is smaller than Saturn.
C. Venus has an atmosphere.
D. Pluto can be seen without a telescope.
E. Mars has a smaller orbit than the earth.

27. (1.1) The factor contributing to the seasonal changes in the temperature latitudes is that

A. the moon revolves around the earth.
B. the earth rotates on its axis.
C. the sunspots vary in magnitude in a regular cycle.
D. the earth's axis is inclined 66½° to the plane of its orbit.
E. the equinoxes precess.

28. (1.1) Which of the following is true of the ecliptic?

A. The ecliptic is the projection of the earth's equator on the celestial sphere.
B. The ecliptic is the true path of the sun among the stars.
C. The ecliptic is the apparent path of the moon among the stars.
D. The ecliptic is the intersection of the plane of the earth's orbit and the celestial sphere.
E. The ecliptic crosses the celestial equator at four points.

29. (1.1) The diurnal motions of the stars are due to the

A. revolutions of the earth about the sun.
B. rotation of the earth on its axis.
C. movement of the solar system relative to the stars.
C. rotation of the sun.
E. actual movement of the stars themselves.

30. (1.24) The orbit of the earth is not a perfect circle. Which one of the following offers the best experimental basis for this conclusion?

A. The sun is not always on the ecliptic.
B. The earth is not a perfect sphere.
C. The gravitational attraction of the moon perturbs the earth.
D. The apparent size of the sun varies during the year.
E. There is a variation in sun-spot activity during the year.

31. (1.1) The angle between the equatorial plane of the earth and the plane of the earth's orbit is

A. 23½°. **B.** 42°. **C.** 48°. **D.** 66½°. **E.** 90°.

32. (1.1) This angle (in item 31) is determined from

A. the change in the plane of vibration of the Foucault pendulum.
B. the variation in the altitude of the fixed stars with changes in the latitude of the observer.
C. the variation in the altitude of the sun at true noon throughout the year.
D. the elevation of the celestial pole.
E. the variation in the apparent diameter of the sun's disk throughout the year.

33. (1.1) The tidal effects of the moon are more than twice those of the sun because

A. the moon in general attracts the earth's hemisphere facing it more powerfully than does the sun.
B. the tidal forces of the moon tend to oppose those of the sun.
C. the difference in attraction of the moon for the near and far sides of the earth is greater than that of the sun.
D. the sun is only a dense gas while the moon is a cold solid.
E. None of these are true because the solar and lunar tides are actually identical, the latter are only theoretically higher.

34. (1.1) The vernal equinox is best defined as

A. A point directly above Greenwich on March 21.
B. A point on the earth's equator directly under the sun on or about March 21.
C. September 21 or 22.
D. The point at which the sun crosses the celestial equator in Spring.
E. A point on the ecliptic where the sun's center is in Spring.

Item 35. Blacken the space corresponding to the best completion of the statement, or to the best answer to the question.

35. (1.1) Which of the following constitute proof that the earth is nearly a sphere?

A. The change in zenith distance of the North Celestial Pole between Chicago and St. Louis and between St. Louis and New Orleans are proportional to the distance between these places.
B. The difference in sidereal time between Chicago, Cleveland, and New York City are proportional to their east-west distances apart.
C. The heavens appear to us as a sphere.
D. The hulls of vessels disappear before their masts in whatever direction they are sailing.
E. None of the above.

Items 36 - 53. The following categories refer to five different locations on the surface of the earth. After each item number on the answer sheet, blacken the *one* lettered space to designate the location for which the item is true

A The North Pole, or 90°N.
B The Arctic Circle, or 66.5°N.
C The Tropic of Cancer, or 23.5°N.
D The equator, or 0°N.
E The Tropic of Capricorn, or 23.5°S.

36. (1.1) This location is farther from the center of the earth than any of the others.

37. (1.1) A person in this location can move only in one direction on the earth's surface.

38. (1.1) In this location the sun would be at a 66.5° altitude at high noon, on June 21.

39. (1.1) When the sun is overhead at this location, the earth is near the perihelion point in its orbit.

40. (1.1) All of the stars may be seen from this location, at one time or another.

41. (1.1) On June 21, from this location the sun is seen at an altitude of 23.5°.

42. (1.1) When the sun is at the zenith in this location, it appears to be at the intersection of the ecliptic and the celestial equator.

43. (1.1) This location is at the boundary of the "land of the midnight sun."

44. (1.1) Here, all year long, there are twelve hours of light and twelve hours of darkness every day.

45. (1.1) September 22 is the last day of six months of daylight in this location.

46. (1.1) To an observer in this location, the stars appear to move in concentric circles about the zenith.

47. (1.1) In this location, the sun never sets on June 21, although it touches the horizon for a moment.

48. (1.1) This location is at the region of the southeast trade winds.

49. (1.1) When observed from this location, the altitude of the North Star is 23.5°.

50. (1.1) Twice during the year the sun is at the zenith for an observer in this location.

51. (1.1) In this location, at the winter solstice the sun appears on the horizon for a moment and then disappears.

52. (1.1) For an observer in this location, the sun is directly overhead at noon on the vernal equinox.

53. (1.1) At noon on December 22, the sun is at the zenith for an observer in this location.

54. (1.1) How do you explain the fact that the plane of the celestial equator makes an angle of approximately 23.5° with the plane of the ecliptic?

A. The axis of the earth is tilted with respect to the plane of the orbit of the earth.
B. The Tropic of Cancer is 23.5° north of the equator while the Tropic of Capricorn is 23.5° south of the equator.
C. The orbit of the earth is an ellipse.
D. The earth is an oblate spheroid.
E. This angular separation is wholly due to the precession of the equinoxes, which in turn is caused by the gyration of the earth's axis.

55. (1.1) The slow but steady decrease in the earth's rate of rotation causes the moon to

A. move farther from the earth.
B. move closer to the earth.
C. rotate at a faster rate.
D. have a shorter period of revolution.
E. undergo none of the above changes.

56. (1.1) The existence of the planet which was later named Pluto was predicted because of

A. Bode's Law. **B.** Kepler's Third Law.
C. Newton's Law of Universal Gravitation.
D. perturbations in the predicted motions of the planet, Neptune.
E. perturbations in the predicted motions of the planet Uranus.

57. (1.1) The planet whose position is not in conformity with Bode's law is

A. Venus **B.** Mars. **C.** Saturn. **D.** Uranus.
E. Neptune.

58. (1.1) Of the following discoveries of Galileo, the one that served as a *direct* verification of the Copernican (heliocentric) concept of the universe was the discovery of

A. four of the moons revolving around Jupiter.
B. the rotation of the sun by observations of sun spots.
C. the phase changes of Venus.
D. the laws of motion governing freely falling bodies.
E. the variegated surface of the moon.

59. (1.1) Proponents of the geocentric theory failed to establish even a partially plausible explanation of

A. stellar parallax.
B. apparent rising and setting of the sun.
C. apparent lack of motion of the Pole star.
D. apparent retrograde motion of the planets.
E. the phase of the moon.

60. (1.1) If a ship traveling westward arrives at the International Date Line at 11 P.M. on July 18, what is the time and day immediately on the other side of this line?

A. 11 A.M. on July 18. **B.** 11 A.M. on July 19.
C. 11 P.M. on July 19 **D.** 11 A.M. on July 20.
E. The correct answer does not appear.

61. (1.1) The solar day is about 4 minutes longer than the sidereal (star) day. This is because

A. the earth's orbit is elliptical.
B. the sun rotates on its axis.
C. the Gregorian calendar is not perfect.
D. the earth moves in its orbit while rotating.
E. of the application of Kepler's Law of Equal Areas.

62. (1.1) The earth is flatter at the poles than at the equator. Which one of the following contributes most to this phenomenon?

A. The earth revolves about the sun.
B. The earth is rotating on its axis.
C. The interior of the earth is liquid.
D. The attraction of the sun produces a bulge at the equator.
E. The expansion of the earth due to heat is greater at the equator.

For items 63 - 68 select the correct answer from the following key.

KEY

A. A star. **B.** A constellation. **C.** A planetoid.
D. A satellite. **E.** A planet.

63. (1.1) Eros. **64.** (1.1) Pluto. **65.** (1.1) The moon.

66. (1.1) Sirius. **67.** (1.1) Ursa Major. **68.** (1.1) The sun.

69. (1.1) One hour of sun time corresponds to how many degrees of earth's rotation?

A. 2½. **B.** 7½. **C.** 15. **D.** 30. **E.** 45.

70. (1.1) We see the same side of the moon at all times because the

A. orbit of the moon is in the same plane as the orbit of the earth.
B. moon's period of rotation equals its period of revolution.
C. orbit of the moon is an ellipse.
D. axis of the moon is inclined to the plane of its orbit.
E. moon does not rotate.

71. (1.1) The moon rises on an average 51 minutes later each day. This lag in the rise of the moon is due to the

A. revolution of the moon in its orbit.
B. revolution of the earth in its orbit.
C. rotation of the earth.
D. inclination of the orbit of the moon to the orbit of the earth.
E. rotation of the moon and its revolution in its orbit.

72. (1.1) Solar days vary slightly in duration because of the

A. variation in orbital speed of the earth.
B. variation in rate of rotation of the earth.
C. slight variation in the inclination of the axis of the earth.
D. annual shift of the stars as observed from the earth.
E. inadequacy of our measuring instruments.

73. (1.1) Leap year, according to our present calendar, is omitted in those century years not divisible by 400. Thus 1900 was not a leap year. This is necessary because

A. the months do not have the same number of days.
B. astronomers say that the year is getting shorter.
C. the year is slightly less than 365¼ days.
D. of the cumulative error of the old calendars over a long period of years.
E. Julius Caesar had shifted the beginning of the year from March to January.

74. (1.1) Total eclipse of the sun occurs only when the moon is new. Why is there not a total eclipse of the sun by the moon once each month?

A. The axis of the earth is tilted.
B. The orbit of the moon is too eccentric.
C. Two solar eclipses can occur during the same month.
D. The distance between the earth and the sun varies during the year.
E. The orbit of the moon is inclined to the ecliptic.

75. (1.1) When the sun is on the Meridian in city X, it is not noon by an ordinary, but accurate clock, chiefly because

A. sidereal time differs from solar time.
B. we do not use daylight saving time.
C. we use time zones.
D. solar days vary considerably throughout the year.
E. the earth is revolving in its orbit about the sun.

76. (1.1) To an observer on Jupiter the

A. earth would be invisible.
B. earth would not show retrograde motions.
C. earth would show phases.
D. edges of the earth would be sharp when crossing the sun's disk.
E. synodic period of the earth would equal its sidereal period.

77. (1.1) A man falling toward the surface of the moon in a parachute would not reach a terminal velocity, because

A. the surface gravity on the moon is too small.
B. the period of rotation of the moon is too long.
C. the moon is covered with deep craters.
D. the moon has no atmosphere.
E. action and reaction are always equal and opposite.

78. (1.1) All through history the production of a satisfactory calendar has been a troublesome problem largely because

A. months vary in their number of days.
B. the time between two arrivals of the sun at the vernal equinox is 365.2422 mean solar days.
C. only in recent times has the problem been well understood.
D. modern clocks and telescopes were needed to attack the problem.
E. it was necessary to know that the earth revolves about the sun.

79. (1.1) Sidereal time is measured by

A. the rotation of the earth with respect to the sun.
B. the revolution of the earth about the sun.
C. the rotation of the earth with respect to the stars.
D. the rotation of the earth with respect to the moon.
E. the revolution of the moon about the earth.

80. (1.1) Why doesn't Mercury transit the sun's disk at every inferior conjunction?

A. Its orbit is too eccentric.
B. Its orbit is greatly inclined to the ecliptic.
C. Both the earth and Mercury may not be in conjunction at the same time.
D. Both the earth and Mercury may not be at perihelion at the same time.
E. Mercury's period is only 88 days.

81. (1.1) Which of the following would you never expect to see at midnight?

A. A full moon. **B.** Venus. **C.** Mars.
D. Jupiter. **E.** Saturn.

82. (1.1) During the annual revolution of the earth around the sun, the centripetal force exerted on the earth by the sun

A. is constant.
B. does not exist because centripetal force does not operate through space.

C. is equal to the gravitational attraction of the sun for the earth.
D. is greater than the centrifugal force due to the motion of the earth.
E. is less than the centrifugal force due to the motion of the earth.

83. In measuring the circumference of the earth by the
(1.1) method of Eratosthenes, one observer notes that a certain star is directly overhead at the same time that another observer in a distant location

A. notes that the star is at its zenith.
B. measures the angle between the star and the horizon.
C. measures the angle between the star and the North Star.
D. measures the angle between the lines from both observers to the star.
E. measures the angle between the star and his zenith.

84. A solar day would exactly equal a sidereal day if the
(1.1)

A. orbit of the earth was a circle.
B. earth would rotate a little more rapidly.
C. earth would rotate a little less rapidly.
D. earth did not revolve, but continued to rotate.
E. solar day did not vary in length during a year.

85. The ecliptic and the celestial equator would be the
(1.1) same if the

A. axis of the earth were at 90° to the plane of the earth's orbit.
B. orbit of the earth were not an ellipse.
C. equator of the earth were not in the same plane as the celestial equator.
D. North Pole did not point toward Polaris.
E. orbit of the earth were not in the plane of the ecliptic.

86. The edge of the zone of the sun's illumination on the
(1.1) earth is a great circle

A. only at the summer solstice.
B. only at the equinoxes. **C.** only at perihelion.
D. at any time. **E.** at none of the above times.

87. The period when the North Pole of the earth tilts most
(1.1) toward the sun is known as

A. one of the solstices. **B.** the spring equinox.
C. the perihelion. **D.** the perigee.
E. the autumnal equinox.

88. Solar time in Denver is different from solar time in
(1.1) New York because of

A. man's invention of the time belts.
B. the inclination of the earth on its axis.
C. the elliptical orbit of the earth.
D. the rotation of the earth.
E. the revolution of the earth.

89. The best evidence that meteors may be the remains of
(1.1) comets is the fact that

A. little damage is done when they strike the earth.
B. many of them are composed of nickel and iron.
C. their light comes from their combustion rather than from the sun.
D. their density approximates that of the nucleus of a comet.
E. many of them travel in groups whose orbits resemble those of comets, some of which no longer reappear.

90. Which of the following events occurs only once a year
(1.1) on earth?

A. Aphelion. **B.** Solstice.
C. Earth's axis perpendicular to the sun's rays.
D. A day the same length as night. **E.** Equinox.

91. The most permanent points of reference for locating
(1.1) position on the earth's surface are the

A. courses of rivers. **B.** shore lines of oceans.
C. location of mountain ranges.
D. boundaries of continents.
E. positions of stars and planets.

For items 92 and 93 select from the key the most appropriate response.

KEY

A. Summer solstice. **B.** Perihelion.
C. Autumn equinox. **D.** Aphelion. **E.** March 21st.

92. A time when the altitude of the sun is a maximum in
(1.1) the northern hemisphere.

93. A position when the distance from the sun to the earth
(1.1) is such that Kepler's Law implies that the earth travels in its orbit at its greatest speed.

94. All of the following are associated with obtaining data
(1.1) on the earth in space *except*

A. dark-line spectra. **B.** isostacy.
C. the Doppler effect. **D.** spectroscopic photographs.
E. the red shift of the spectrum.

95. Which of the following planets is most remote from
(1.1) the sun?

A. Jupiter. **B.** Neptune. **C.** Saturn. **D.** Pluto.
E. Uranus.

96. The factor having the greatest bearing upon the sea-
(1.1) sonal change in the temperate latitudes is

A. the distance to the sun is about 3 million miles less at one time of year than at any other time.
B. there is much more land surface in the northern hemisphere than in the southern.
C. the sunspots vary in magnitude in a regular cycle.
D. the earth's axis is inclined 23½ degrees to the ecliptic.
E. the equinoxes precess.

97. Which one of these is *not* related to the rotation of the
(1.1) earth?

A. A sun dial may be used to tell time.
B. Even though the earth were a perfect sphere, an object on a spring balance would weigh less at the equator than at the poles.
C. Different constellations appear in the sky in March than December.
D. Airplanes can make better time flying east than west.
E. Michigan lies in the westerly wind belt.

For items 98 - 101 select from the key the name of the planet which answers the description.

KEY

A. Jupiter. **B.** Neptune. **C.** Pluto. **D.** Saturn.
E. Uranus.

98. A planet which seems to rotate on its axis in a direc-
(1.1) tion opposite to that of the other planets.

99. A planet which has four satellites.
(1.1)

100. A planet which was not discovered until 1930.
(1.1)

101. A planet which is the smallest of the above group.
(1.1)

For items 102 - 105 select from the key the name of the planet which answers the description.

KEY

A. Earth. **B.** Mars. **C.** Mercury. **D.** Venus.

102. A planet which is about 1.5 astronomical units from the sun.
(1.1)

103. A planet which is continually covered with clouds.
(1.1)

104. A planet which is most similar in size to the earth.
(1.1)

105. A planet which has the shortest period of revolution.
(1.1)

106. Which one of these statements is correct?
(1.1)

A. Pluto is one of the warmer planets.
B. The earth has the shortest year of all the planets.
C. Jupiter is smaller than Mars.
D. The orbit of Mercury is smaller than that of the earth.
E. Venus has no atmosphere.

107. The most widely accepted hypothesis for the origin of the earth is the
(1.1)

A. Gaseous Tidal. **B.** Binary Star. **C.** Nebular.
D. Planetesimal. **E.** Radioactive.

For items 108 - 112 select from the key the most appropriate planet.

KEY

A. Jupiter. **B.** Neptune. **C.** Saturn. **D.** Pluto.
E. Uranus.

108. Most remote from the sun.
(1.1)

109. Smallest.
(1.1)

110. Closest to the earth.
(1.1)

111. With rings.
(1.1)

112. Largest.
(1.1)

For items 113 - 117 select from the key the most appropriate planet.

KEY

A. Earth. **B.** Venus. **C.** Mars. **D.** Mercury.

113. Has the highest surface temperature.
(1.1)

114. Is the densest.
(1.1)

115. Has the lowest average surface temperature.
(1.1)

116. Appears reddish in color.
(1.1)

117. Is 1.5 astronomic units from the sun.
(1.1)

118. An eclipse of the moon can occur at
(1.1)

A. full moon. **B.** new moon. **C.** half moon.
D. two of the above. **E.** any of the first three.

119. The period when the distance from the south pole of the earth most exceeds the distance of the north pole to the sun is designated
(1.1)

A. one of the solstices. **B.** the spring equinox.
C. the perihelion. **D.** the apogee.
E. the autumnal equinox.

120. The planet which sometimes transits the sun (appears to cross the surface of the sun as a black dot) is
(1.1)

A. Jupiter. **B.** Saturn. **C.** Pluto. **D.** Mercury.
E. Mars.

For items 121 - 124 select from the key the most appropriate response.

KEY

A. Summer solstice. **B.** Perihelion.
C. Autumn equinox. **D.** Aphelion.
E. None of these.

121. A time when the poles of the earth are in a plane perpendicular to a line from the earth to the sun.
(1.1)

122. A position when the distance from the earth to the sun is such that Kepler's Laws imply that the earth travels in its orbit at its greatest speed.
(1.1)

123. Representing a position when the distance from the earth to the sun is actually less than the astronomical unit.
(1.1)

124. A time when the altitude of the sun is a maximum in the northern hemisphere.
(1.1)

Items 125 - 129 refer to the knowledge which is usually associated with certain men. For each item select from the key the most appropriate response.

KEY

A. Copernicus. **B.** Galileo. **C.** Kepler.
D. Ptolemy. **E.** Tycho Brahe.

125. A planet moves in a small circle called an epicycle around a point which moves in the orbit of the planet around the earth.
(1.1)

126. The astronomer who suggested the most radical departure from the views held by other astronomers before his time.
(1.1)

127. The astronomer to whom we owe the concept that the distance from the earth to the sun varies during the year.
(1.1)

128. In appropriate units of measurement, the square of the period of revolution of a planet around the sun is equal to the cube of its distance from the sun.
(1.1)

129. The astronomer who proposed that the planets revolve around the sun in circular orbits.
(1.1)

130. The only body which is one astronomical unit from the earth is
(1.1)

A. the nearest star. **B.** the sun. **C.** Mars.
D. the moon. **E.** Pluto.

131. We see approximately the same side of the moon at
(1.1) all times because the

A. moon's period of rotation equals its period of revolution.
B. moon does not rotate.
C. orbit of the moon is an ellipse.
D. axis of the moon is inclined to the plane of its orbit.
E. orbit of the moon is in the same plane as the orbit of the earth.

132. Which of these generally are the largest?
(1.1)

A. Comets. **B.** Planetoids. **C.** Meteors.
D. Asteroids. **E.** Meteorites.

133. The superior planets are
(1.1)

A. those which are larger than the earth.
B. those which could have some form of life.
C. those which are visible to the naked eye at some times.
D. those which have longer periods of revolution than the earth.
E. those which have orbits smaller than that of the earth.

134. Craters on the moon
(1.1)

A. are probably volcanic in origin.
B. were formed by meteorites or meteoric swarms.
C. resulted after huge gas bubbles broke through from the interior.
D. resulted from tidal action when the moon was in a molten state.
E. have not been satisfactorily explained by any hypothesis.

135. When it is 9 P.M. Eastern Daylight Time in New York,
(1.1) the Pacific Standard Time in Los Angeles is

A. 5:00 P.M. **B.** 12:00 midnight. **C.** 6:00 P.M.
D. 11:00 P.M. **E.** 7:00 P.M.

136. The sun is farthest away from a resident of Michigan
(1.1) at the

A. middle of the winter. **B.** summer solstice.
C. fall equinox. **D.** spring equinox.
E. winter solstice.

137. Mars appears brightest at opposition, because it
(1.1)

A. is closer to the sun than to the earth.
B. has an elongation of 90°.
C. is closest to the earth and is in full phase.
D. rises at sunset.
E. is on the meridian of the observer at midnight.

138. The diurnal motions of the stars are due to the
(1.1)

A. revolution of the earth about the sun.
B. rotation of the earth on its axis.
C. movement of the solar system relative to the stars.
D. rotation of the sun.
E. actual movement of the stars themselves.

139. Sidereal time is measured by
(1.1)

A. the rotation of the earth with respect to the sun.
B. the revolution of the earth about the sun.
C. the rotation of the earth with respect to the stars.
D. the rotation of the earth with respect to the moon.
E. the revolution of the moon about the earth.

140. The orbits of the four largest planets are between the
(1.1) orbits of

A. Mars and Uranus. **B.** Mars and Neptune.
C. Mars and Pluto. **D.** Jupiter and Neptune.
E. the earth and Uranus.

141. Two planets that can be in either superior conjunction
(1.1) or inferior conjunction with respect to the earth are

A. Mars and Jupiter. **B.** Jupiter and Saturn.
C. Saturn and Uranus. **D.** Uranus and Neptune.
E. Mercury and Venus.

142. When the moon is at first quarter, it rises__________
(1.1) the sun.

A. with. **B.** six hours after. **C.** twelve hours after.
D. six hours before. **E.** seasonally before or after.

143. If a star appears on the meridian at 9:00 P.M., it will
(1.1) appear on the meridian the next night at about

A. 8:00 P.M. **B.** 8:45 P.M. **C.** 8:56 P.M.
D. 9:04 P.M. **E.** 9:15 P.M.

144. What evidence that the earth revolves about the sun was
(1.1) not available to Tycho Brahe or to Galileo, although both recognized the significance of such evidence?

A. Observation of the phases of Venus.
B. The transit of Venus across the sun's disk.
C. Revolution of the satellites of Jupiter.
D. Fluctuations of the Cepheid variables.
E. Annual parallactic displacement of stars.

145. Why doesn't Mercury transit the sun's disk at every
(1.1) inferior conjunction?

A. Its orbit is too eccentric.
B. Its orbit is greatly inclined to the ecliptic.
C. Both the earth and Mercury may not be in conjunction at the same time.
D. Both the earth and Mercury may not be at perihelion at the same time.
E. Mercury's period is only 88 days.

146. A long exposure photograph of the zenith stars taken
(1.1) at the North Pole discloses

A. star trails that are arcs of concentric circles about the North Star.
B. the courses of the planets in the region of the North Celestial Pole.
C. star trails that are parallel straight lines.
D. the area of the North Celestial Pole, but no star trails since the camera is only rotating.

147. Two circles are concentric if they have the same center
(2.1) and are in the same plane, but have different radii. An example is

A. the orbit of the earth and the celestial equator.
B. the equator of the earth and the celestial equator.
C. any two different meridian circles.
D. the Tropic of Cancer and the Tropic of Capricorn.
E. the circumference of the sun and the orbit of the earth.

148. (1.25) Simultaneous measurement of the altitude of the same star by observers in Chicago and New Orleans could be used in determining

A. how much the earth is flattened at its poles.
B. the radius of the earth.
C. the rate at which the earth is moving in its orbit about the sun.
D. the radius of the earth's orbit.
E. the parallax of the star observed.

149. (2.4) The change in the sun's measured angular diameter from June to January can best be explained by

A. an annual variation in the sun's real size.
B. the annual variation in the sun's noon altitude.
C. the change in the optical properties of air from summer to winter.
D. the eccentricity of the earth's orbit.

150. (1.1) The meridian of the celestial sphere is defined as a great circle through the celestial poles and the

A. observer's zenith.
B. azimuth of the star under consideration.
C. visible horizon. **D.** celestial equator.

151. (1.1) Solar days are not all of equal length because

A. all mean solar days are of equal length.
B. the earth's axis of rotation is not perpendicular to the ecliptic.
C. it is too difficult to measure precisely two successive transits of the center of the sun across the meridian.
D. the orbital speed of the earth is not constant throughout the year.

152. (1.1) The latitude of Chicago is 42°N. An observer in Chicago notes that a star has a constant altitude of 42°. The star is

A. Proxima Centauri. **B.** Vega. **C.** Sirius.
D. Polaris. **E.** the sun.

Items 153 - 160.

After each item number on the answer sheet, blacken space

A if the item in the left column is greater than or indicates a later time than that in the right column.
B if the item in the right column is greater than or indicates a later time than that in the left column.
C if the two items are the same or very nearly so.

153. (1.1)	Length of sidereal day.	....	Length of a mean solar day.
154. (1.1)	Number of mean solar days in a year.	....	Number of sidereal days in a year.
155. (1.1)	Longitude of place which has noon at 9 P.M. Greenwich time.	....	Longitude of place which has noon at 6 P.M. Greenwich time.
156. (1.1)	Altitude of Polaris.	....	Latitude of observer.
157. (1.1)	Angle between celestial equator and ecliptic.	....	Angle between earth's axis and the perpendicular to plane of earth's orbit.
158. (1.1)	Time any star (not the sun) rises today.	....	Time the same star rises a year from now.
159. (1.1)	Altitude of the horizon.	....	Altitude of the zenith.
160. (1.1)	Apparent diameter of the sun in winter in the northern hemisphere.	....	Apparent diameter of the sun in summer in the northern hemisphere.

161. (1.1) When traveling west across the international date line

A. 24 hours are added to the time.
B. 12 hours are subtracted from the time.
C. 24 hours are subtracted from the time.
D. 12 hours are added to the time.
E. none of the above is done.

Items 162 - 166. From the key list of five hypotheses concerning the origin of the solar system, select the most appropriate for each item.

KEY

A. Double star hypothesis of Russell and Lyttleton.
B. Dust cloud hypothesis of Whipple.
C. Nebular hypothesis of Laplace.
D. Planetesimal hypothesis of Chamberlain and Moulton.
E. Tidal hypothesis of Jeans.

162. (1.1) Has greatest difficulty in accounting for the existing distribution of angular momentum.

163. (1.1) Proposed in response to a serious objection raised by Lyman Spitzer.

164. (1.1) Of those which assume that planetary material came from our sun, would require the least time for the process.

165 (1.1) Was accepted for the longest period of time.

166. (1.1) Would require the greatest number of special conditions to be met at one time.

Items 167 - 177. After each item number on the answer sheet, blacken space

A if the item is true of the geocentric theory of Ptolemy *alone.*
B if the item is true of the heliocentric theory of Copernicus *alone.*
C if the item is true of the heliocentric theory of Kepler *alone.*
D if the item is true of *both* heliocentric theories.
E if the item is true of *all* of the above theories.

167. (1.1) The planets revolve about the sun in circular orbits.

168. (1.1) The moon revolves about the earth.

169. (1.1) Day and night is caused by the revolution of the sun about the earth.

170. (1.1) Venus and Mercury exhibit phases like the moon.

171. (1.1) The planets revolve about the sun in elliptical orbits.

172. (1.1) The orbits of the planets are characterized by large epicycles.

173. (1.1) Day and night is caused by the rotation of the earth.

174. (1.1) At times, Venus and Mars are on opposite sides of the sun.

175. (1.1) Accounts for the apparent retrograde motions of the planets in terms of different speeds of the planets in the same general direction.

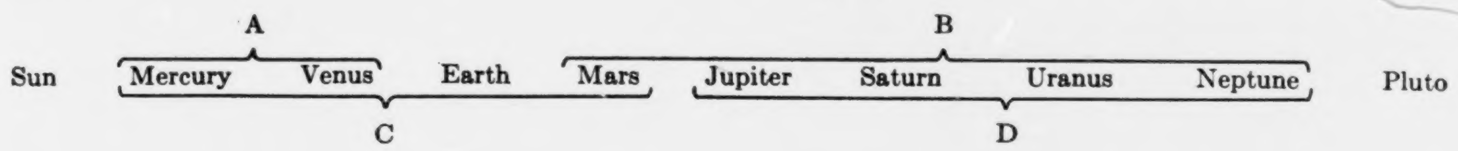
176. (1.1) Truth of the theory is supported by annual parallactic displacement of the stars.

177. (1.1) The orbital speed of each planet varies with its distance from the sun.

Items 178 - 189.

From left to right below are the names of the planets in order of their distances from the sun. The inferior planets are labeled A, the superior planets B, the inner planets C, and the outer planets D.

After each item number on the answer sheet, blacken the *one* lettered space which designates the group of planets to which the item correctly refers. If the item refers to all of the planets, blacken space *E*.



178. (1.10) Sun is at a focus of these elliptical orbits.

179. (1.10) Obey the Keplerian Laws of Motion.

180. (1.1) Large in mass, but low in density.

181. (1.10) Periods of revolution greater than one year.

182. (1.10) Are never seen at midnight.

183. (1.10) Transit the sun's disc as seen from the earth.

184. (1.10) Periods of revolution less than one earth year.

185. (1.10) Small in mass, but high in density.

186. (1.10) Exhibit phases like the moon.

187. (1.10) Orbital speeds minimum at aphelion.

188. (1.10) Revolve about the sun in elliptical orbits.

189. (1.10) Distances from the sun are greater than one astronomical unit.

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190. (1.10) The planet Mars

A. is invisible without a telescope.
B. has a larger orbit than the earth.
C. is larger than the earth.
D. has no atmosphere. **E.** has only one season.

191. (1.10) Which one of these statements is true?

A. Pluto is one of the warmer planets.
B. The earth has the shortest year of all the planets.
C. Jupiter is smaller than Mars.
D. The orbit of Mercury is smaller than that of the earth.
E. Venus has no atmosphere.

192. (4.20) It is commonly said that people in general in ancient times believed that the earth is flat. If ancient astronomers had also believed this, they would have been unable to measure the

A. altitude of the sun. **B.** time of the solstices.
C. size of the earth. **D.** time of day.
E. length of the year.

193. (3.00) If you wanted to calculate most easily the size of the earth from the altitude of the noonday sun in Chicago on March 21st, the best place to have someone simultaneously measure the sun's altitude would be at

A. New Orleans. **B.** Los Angeles. **C.** New York.
D. Denver. **E.** Miami.

194. (1.10) The tradewinds blow from the northeast in the northern hemisphere and from the southeast in the southern hemisphere, rather than directly south and directly north. This is attributed to the fact that

A. the earth revolves around the sun.
B. the axis of the earth is tilted.
C. the earth is an oblate spheroid.
D. the earth rotates.
E. warm air is lighter than cold air.

195. (1.10) At some times during summer in the southern hemisphere, the distance between the earth and the sun is at its

A. maximum. **B.** zenith. **C.** minimum.
D. average amount.

196. (1.10) For Chicago which is at 42°N. latitude, the altitude of the celestial equator is

A. 42°. **B.** 23½°. **C.** 48°. **D.** 0°. **E.** 90°.

197. (1.10) For a person in Chicago, the angle between his zenith and his celestial horizon is

A. 42°. **B.** 23½°. **C.** 48°. **D.** 0°. **E.** 90°.

198. (2.10) If we used sidereal days instead of mean solar days to measure the number of days in our present or tropical year, we would have

A. more days. **B.** less days.
C. the same number of days.

199. (2.40) A Chicagoan notes that it is exactly 12 noon by his watch, yet the sun is not on his meridian. One reason that this occurs is

A. each time zone is about one thousand miles wide.
B. the sun is not on the meridian at noon local time.
C. the position of the sun changes during the year.
D. the axis of the earth is tilted toward the sun only half of the year.
E. meridians are always fifteen degrees apart.

200. (1.10) If you lived in New Orleans, the duration of daylight on June 21st would be

A. exactly the same as in Chicago.
B. less than in Chicago.
C. greater than in Chicago.

201. (2.40) The sun shines on the North Pole area day and night for almost six months every year yet it is extremely cold there during this time. The reason for this is that

A. there are large areas of water which are difficult to heat up.
B. there are large land areas which are difficult to heat up.
C. the other six months there is no sun at all.
D. at no time is the altitude of the sun very high.
E. the rotational speed of the pole area is much smaller than that of the equatorial area.

202. (3.00) To observe the noon-day sun at one's zenith on June 21st, one could take a trip to

A. Fairbanks, Alaska. **B.** New York, N. Y.
C. Havana, Cuba. **D.** Quito, Ecuador.
E. Buenos Aires, Argentina.

203. (3.00) If you wanted a house in Chicago with the maximum amount of sunshine possible through the living room windows, you would select a lot on the

A. north side of an east-west street.
B. south side of an east-west street.
C. east side of a north-south street.
D. west side of a north-south street.

Items 204 - 213. After each item number on the answer sheet, blacken space

A if the item is true of the moon.
B if the item is true of the planet Venus.
C if the item is true of the planet Mars.
D if the item is true of the planet Jupiter.
E if the item is true of all of the above.

204. (1.10) Its period of revolution about the sun is the greatest.

205. (1.10) Its period of rotation equals its period of revolution.

206. (1.10) Its orbit is elliptical.

207. (1.10) It is never seen at midnight.

208. (1.10) Appears to have polar caps, faint clouds, seasons twice as long as the earth's, and possible vegetation.

209. (1.10) Could be reached most quickly from the earth by a space ship.

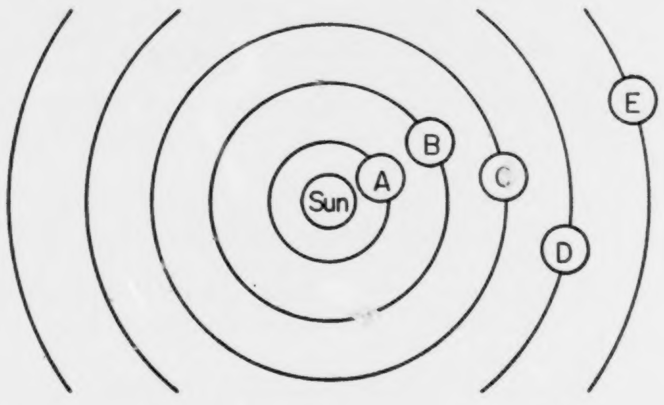
210. (1.10) It is least dense, rotates most rapidly, and hence, is most flattened at its poles.

211. (1.10) It is almost as large as the earth, almost as dense as the earth, but dense clouds seem to obscure observation of its surface.

212. (1.10) Its motion is in accordance with Kepler's laws.

213. (1.10) Some astronomers have interpreted their observations of it as revealing "canals."

Items 214 - 224. After each item number on the answer sheet, blacken the *one* lettered space corresponding to the letter of the planet which best answers the question.



Assume that the circles represent the orbits of the five planets closest to the sun.

214. (1.10) For which planet do four others exhibit phases?

215. (1.10) Which of the above planets is closest to the earth when the planet is at opposition?

216. (1.10) Which planet is very difficult to observe?

217. (1.10) Which planet is largest in diameter and least dense?

218. (1.10) Galileo observed the phases of which of these planets?

219. (1.10) Which planet appears red to an observer on the earth?

220. (1.10) For which planet is the period of revolution greatest?

221. (1.10) Which planet has its orbit exactly in the plane of the ecliptic?

222. (1.10) Which planet is the earth?

223. (1.10) Which planet is surpassed only by the sun and moon in brightness to an observer on the earth.

224. (1.10) Which planet has markings at one time interpreted to be canals?

225. (1.10) The fact that an eclipse of the sun does not occur each time the moon is in this phase is explained by the fact that

A. the moon is much smaller than the sun.
B. the moon is much smaller than the earth.
C. the moon is not generally on the ecliptic.
D. the distance of the moon from the earth is not constant.
E. the sun is on the celestial equator only twice a year.

226. (1.10) An eclipse of the sun can occur only when the moon is

A. crescent. **B.** half full, and waxing (first quarter).
C. full. **D.** half full and waning (third quarter).
E. entirely dark.

227. "Retrograde motion" of a planet is observed as
(1.10)

- **A.** motion across the sky from west to east, in the course of a night.
- **B.** a time-interval between successive risings of the planet, shorter than the corresponding time-interval for a fixed star.
- **C.** a time-interval between successive risings of the planet, longer than the corresponding time-interval for a fixed star.
- **D.** a time-interval between successive risings of the planet, longer than the corresponding time-interval for the sun.
- **E.** a reversal of the sequence of the planet's phases—e.g., from full, to third quarter, back to full.

228. Such motion is called "retrograde" because
(1.10)

- **A.** the direction of the observed motion of the planet through the night sky is contrary to that of most of the objects visible in the sky.
- **B.** the direction of the observed motion of the planet through the night sky is contrary to that of the usual direction of motion of that planet.
- **C.** the direction of the motion of the planet in its orbit about the sun, which is indicated by the observed phenomenon, is contrary to the usual direction of motion of that planet.
- **D.** the direction of the motion of the planet in its orbit about the sun, which is indicated by the observed phenomenon, is contrary to the direction of motion of most other planets.
- **E.** the direction of motion of the planet in the sky relative to the positions of the fixed stars, is contrary to the usual direction of motion of all the planets.

229. "Retrograde motion" of a planet is correctly defined as
(1.10)

- **A.** daily motion from east to west, relative to a terrestrial observer's horizon.
- **B.** daily motion from west to east, relative to a terrestrial observer's horizon.
- **C.** motion from east to west in the planet's orbit about the sun.
- **D.** motion from west to east in the planet's orbit about the sun.
- **E.** motion from east to west with respect to the fixed stars.

230. In order to answer the question "Which planet has the
(1.24) lowest average surface temperature?" information would be most helpful regarding

- **A.** the comparative distance of the planets from the sun.
- **B.** whether the planet's axis is inclined in relation to the plane of its orbit.
- **C.** whether the planet has an atmosphere.
- **D.** the comparative speeds of rotation of the planets.
- **E.** the comparative orbital speeds of the planets.

For items 231 - 235 select from the key the most appropriate **statement.**

- **A.** The statement is *true.*
- **B.** The statement is *false.*
- **C.** The facts of the situation have not yet been established.
- **D.** The statement may be *true at certain times* but *false* at other times.

231. The moon is seen full (on the latitude of Lansing,
(1.24) Michigan) in the evening in the east but never full in the early morning in the east.

232. An eclipse of the sun occurs when the moon is on the
(1.24) same side of the earth as the sun.

233. It is possible for Mars to be on the opposite side of the
(1.24) sun from the earth.

234. The craters of the moon are volcanic in origin.
(1.24)

235. All parts of the surface of the moon are essentially alike
(1.24) in topography.

236. The longitude of a point on the earth's surface may be
(1.25) determined by

- **A.** comparing time at the location of the point with Greenwich time.
- **B.** measuring the apparent angular diameter of the moon.
- **C.** measuring the parallax of the sun.
- **D.** measuring the altitude of Polaris.
- **E.** determining the sidereal time of the meridional transit of the north celestial pole.

237. The earth's atmosphere extends to at least 40 miles
(1.10) above its surface. Which one of the following offers the most direct observational support of the statement?

- **A.** The density of the atmosphere decreases with altitude.
- **B.** Hydrogen and helium are light enough to rise to at least 100 miles.
- **C.** Meteors usually become visible at heights greater than 50 miles from the surface.
- **D.** The atmosphere must be more than 1% of the radius of the earth.
- **E.** Molecules of air do not escape from the earth's attraction at altitudes of less than 40 miles.

Items 238 - 239 deleted.

Items 240 - 250.

After the number on the answer sheet which corresponds to that of each of the following paired items blacken space

- **A** if increase in one of the things referred to is accompanied by increase in the other, or if decrease in one is accompanied by decrease in the other.
- **B** if increase in one of the things referred to is accompanied by decrease in the other.
- **C** if one of the things referred to remains constant, or approximately constant, while the other increases or decreases.

Assume that other factors do not interfere with the conditions specified.

240. The altitude of the North Star for an observer in the
(1.22a) northern hemisphere—the latitude of the observer.

241. The length of a day (from sunrise to sunset) at the
(1.22a) equator—the number of days elapsed since last December 22.

242. The area swept over by a line from a given planet to the
(1.22a) sun in a given interval of time—the distance of the planet from the sun.

243. The force of attraction between a given planet and the
(1.22a) sun—the distance from the planet to the sun.

244. (1.22a) The length of a night (from sunset to sunrise) in Chicago—the number of days elapsed since last December 22. (It is before June 21.)

245. (1.22a) The variability of the speed of a planet—the eccentricity of the orbit of the planet.

246. (1.22a) The temperature along a given isotherm—the distance one travels along the isotherm.

247. (1.22a) The rate at which the barometric pressure falls—chances that it will rain or snow.

248. (1.22a) The tendency of dew to form during the night—the proportion of the sky covered by clouds.

249. (1.22a) The size of the orbit of a planet—the period of revolution of a planet.

250. (1.22a) Area swept over by a line joining a given planet and the sun—the interval of time during which the motion of the planet is measured.

251. (1.24) Evidence that the earth is an oblate spheroid rather than a perfect sphere may be obtained by

A. observing the shadow of the earth on the moon.
B. measuring "g" at the equator and at the poles.
C. using photography at a high altitude.
D. measuring the radius of the centrosphere.
E. taking simultaneous observations of a star at different locations on the surface of the earth.

252. (1.24) The earth's orbit is not a circle. Which of the following offers the most direct experimental support for this statement?

A. The average temperature varies seasonally.
B. The angular diameter of the sun changes slightly during the year.
C. Eclipses occur.
D. The sun has an apparent motion among the stars.
E. Nearby stars show parallax.

253. (1.24) Which of the following constitutes direct observational evidence that the orbit of the earth is an ellipse rather than a circle?

A. Measurement of the orbits of the other planets has shown them to be elliptical rather than circular.
B. Variation in the sun's apparent size.
C. Observation of the changing plane of swing of a Foucault pendulum.
D. Variation in length of the mean solar day.
E. Observation of the sun's apparent path among the stars.

254. (1.24) The early supporters of the Copernican theory couldn't explain Tycho Brahe's observations of the planets because

A. they assumed the planetary orbits to be circles.
B. they assumed gravitation varied directly as the distance between bodies.
C. they thought the sun was only 20 times as far distant as the moon.
D. they assumed that Mars revolves about the earth.
E. the positions Brahe obtained were too rough to use.

255. (1.24) The moon and all the planets lie on or near the plane of the ecliptic and revolve in the same direction about the sun. This is considered a notable fact chiefly because

A. if the moon did not lie on or near the ecliptic there would be no eclipses of the sun.
B. it serves as a means of differentiating planets from other heavenly bodies.
C. it points to a common and simultaneous origin of the various parts of the solar system.
D. it simplifies computation.

256. (1.24) Which of the following is the best evidence that the earth moves around the sun?

A. The sun is larger than the earth.
B. The angular diameter of the sun changes throughout the year.
C. Some stars appear to move slightly during the year with reference to the background of other stars.
D. The plane in which a pendulum swings appears to change with respect to compass directions.
E. The zenith distance of the sun at noon varies in a yearly cycle.

257. (1.24) Whether or not a force is necessary to change a pendulum's plane of swing

A. is vital to Foucault's evidence that the earth rotates.
B. has no bearing on the validity of Foucault's conclusion from his experiment.
C. doesn't matter; the movement of the stars in the sky proves that the earth does not rotate.
D. doesn't matter; the movement of the stars in the sky proves that the earth rotates.

258. (1.24) The fact that, at the time at which the moon is seen to be eclipsed, the sun, the moon and the earth are calculated to be in a straight line shows

A. that the speed of light is infinite.
B. that the speed of light is finite.
C. nothing about the speed of light.
D. that the speed of light exceeds a certain value.
E. that the speed of light is less than a certain value.

259. (1.24) Which of the following statements is evidence of tidal friction between a satellite and its primary?

A. As Mercury revolves around the sun, it always turns the same face toward the sun.
B. Venus has a very thick atmosphere.
C. The earth moves fastest along its orbit when it is closest to the sun.
D. The outer planets have thin atmospheres which consist of hydrogen, helium, and methane.
E. Jupiter, Saturn, and Uranus have "days" of about ten hours duration.

260. (1.24) Which of the following constitutes the indisputable evidence that the earth rotates?

A. Each day, the sun rises in the east and sets in the west.
B. Star trails at the poles are circles.
C. A pin on the bob of a Foucault pendulum traces different paths in sand below the pendulum.
D. The annual shift of near stars as compared with more distant stars.
E. The solar day varies in length.

For items 261 - 267 select from the key the statement which the item most strongly supports.

A. The earth revolves about the sun.
B. The earth rotates on its axis.
C. The axis of the earth is inclined at an angle of 66.5° with the plane of its orbit.

- **D.** The orbit of the earth is an ellipse with the sun at one focus.
- **E.** The earth is nearly spherical.

261. (1.24) The Foucault pendulum did not continue to follow the trace of the line on which it was started.

262. (1.24) The sun when photographed is larger at perihelion than at aphelion.

263. (1.24) The length of day and night varies during the year except at the equator.

264. (1.24) Photographs of the sky in the neighborhood of the pole-star show star trails to be concentric circles.

265. (1.24) Twelve different constellations of the zodiac may be seen during the year.

266. (1.24) The gravitational pull of the earth is greatest at the poles.

267. (1.24) The seasons vary in their average temperatures.

Items 268 - 276. After each item number on the answer sheet, blacken space

- **A** if the statement is evidence that the earth is approximately a sphere.
- **B** if the statement is evidence that the earth rotates on its axis.
- **C** if the statement is evidence that the earth revolves about the sun.
- **D** if the statement is evidence that the orbit of the earth is an ellipse.
- **E** if the statement is evidence that the axis of the earth is inclined to the plane of the ecliptic.

268. (1.24) During the year the nearer stars appear to move with respect to the more distant stars in the background.

269. (1.24) Star trails observed from a position near the North Pole are nearly circular.

270. (1.24) In January the sun appears to be larger in diameter than in June.

271. (1.24) As one travels in a north-south direction, new stars come into view and others formerly visible may no longer be seen.

272. (1.24) The celestial equator is inclined to the ecliptic.

273. (1.24) On a clear day the superstructure of an approaching ship at sea becomes visible before the hull can be seen.

274. (1.24) The altitude of the sun in the sky at noon in Chicago changes throughout the year.

275. (1.24) The length of the solar day varies despite the uniformity of the earth's rotational velocity.

276. (1.24) More of the earth's surface becomes visible to an observer in a balloon as it ascends to higher altitudes.

277. (1.30) The retrograde motion of Mars is now explained by the fact that

- **A.** the earth revolves faster than Mars.
- **B.** there are epicycles in the orbit of Mars.
- **C.** Mars revolves more rapidly than the earth.
- **D.** the rotation of the earth displaces the observer.
- **E.** there is a shift in the background stars.

278. (1.30) When the moon is in conjunction with the sun the

- **A.** dark portion of the moon is turned toward the sun.
- **B.** moon is full.
- **C.** moon is on the meridian at noon.
- **D.** moon is twelve hours behind the sun.
- **E.** moon rises as the sun sets.

279. (2.20) Telescopic examination tells us that there are no clouds nor storms, no evidence of erosion, no twilight nor refraction of light on the moon. We may conclude from this evidence that the moon

- **A.** rotates once on its axis while making a single revolution.
- **B.** revolves about the earth in one sidereal month.
- **C.** and the sun combine their forces to produce extremely high tides.
- **D.** rises and sets on the average of fifty-one minutes later each day.
- **E.** has no appreciable atmosphere and experiences extremely hot and cold temperature.

280. (1.10) Lunar eclipses occur when the

- **A.** moon is in conjunction with the sun.
- **B.** earth is on a line between the sun and the moon.
- **C.** moon passes between the sun and the earth.
- **D.** sun passes between the earth and the moon.
- **E.** moon's axis is tilted 12.2° from the vertical.

281. (1.10) The "other side" of the moon has never been seen by astronomers because the

- **A.** moon does not rotate on its axis.
- **B.** moon is in eclipse when the other side is exposed.
- **C.** period of rotation of the moon is exactly one day.
- **D.** phases of the moon are never complete.
- **E** periods of revolution and rotation of the moon are equal.

282. (2.20) When the moon passes between the earth and a star, the star disappears instantly and later reappears just as suddenly. This fact supports the *hypothesis* that the moon

- **A.** rotates on its axis.
- **B.** revolves about the earth.
- **C.** has a low velocity of escape.
- **D.** is moving in its orbit at a more or less uniform rate.
- **E.** has no atmosphere.

283. (1.10) The moon rises on an average 51 minutes later each day. This lag in the rise of the moon is due to the

- **A.** revolution of the moon in its orbit.
- **B.** revolution of the earth in its orbit.
- **C.** rotation of the earth.
- **D.** inclination of the orbit of the moon to the orbit of the earth.
- **E.** rotation of the moon and its revolution in its orbit.

284. (1.10) Extremely high tides are most likely to occur

- **A.** only when the moon is new.
- **B.** only when the moon is full.
- **C.** only in the spring.
- **D.** only when the moon is either new or full.
- **E.** only when the earth is closest to the sun.

285. (1.10) Venus shows changes in phase just like those of the moon, because

A. it revolves about the earth.
B. it revolves in an orbit between the sun and the earth.
C. it has a different period of rotation than the earth.
D. the earth rotates.
E. the earth revolves around the sun.

286. (1.10) The planet Neptune was discovered as a result of the study of irregularities in the orbit of Uranus. Most crucial to the success of the study was knowledge of the

A. fact that the orbits of the planets are ellipses.
B. fact that a line from the center of a planet to the center of the sun sweeps over equal areas in equal intervals of time.
C. existence of the planet, Pluto.
D. law of gravitation.
E. fact that the force of attraction of Uranus for the unknown planet should equal the force of attraction of the unknown planet for Uranus.

287. (2.30) If the tail of a comet struck the earth, which of the following would most likely occur?

A. Nothing. **B.** A shower of meteors.
C. Gases poisoning our atmosphere.
D. The tail burning in air.
E. The obscuring of the sun.

288. (1.30) The eventual discovery of a tenth planet in the solar system at a distance of about 7×10^9 miles (about twice the distance of Pluto) has been predicted by Karl Schutte of Munich. Such a prediction could be based on a consideration of

A. Bode's Law. **B.** Kepler's Laws of Motion.
C. Newton's Law of Universal Gravitation.
D. the distribution of the orbits of comets.
E. any or all of the above.

289. (1.30) Any hypothesis of the origin of the solar system must include or explain a number of features of the system. Which one of the following would not have to be explained in an evolutionary hypothesis?

A. The regularity and organization among the major bodies.
B. The tidal effect of the moon on the earth.
C. The chemical composition of the system.
D. The distribution of mass and angular momentum in the system.
E. None of the above.

290. (1.30) If a planet travels in an ellipse around the sun its speed should be

A. constant throughout the whole orbit by the principle of conservation of energy.
B. greatest when the planet is nearest to the sun.
C. least when the planet is nearest to the sun.
D. perhaps not constant, but greater than if it were a circular orbit.

291. (1.30) During the annual revolution of the earth around the sun, the centripetal force exerted on the earth by the sun

A. is constant.
B. does not exist because centripetal force does not operate through space.
C. is equal to the gravitational attraction of the sun for the earth.
D. is greater than the centrifugal force due to the motion of the earth.
E. is less than the centrifugal force due to the motion of the earth.

292. (1.30) The unusual motions of the planet Mercury can be explained by

A. the theory of relativity.
B. the quantum theory.
C. Newton's Law of Universal Gravitation.
D. Kepler's Law of Equal Areas.
E. none of the above.

293. (1.30) The heliocentric theory developed all of these points *except*

A. the sun is the center of the solar system.
B. a clearer and simpler explanation of planetary movement.
C. the greater the distance from the sun, the greater the mass of the planet.
D. such a planet revolves around the sun in the same direction.
E. a line joining the center of any planet to the center of the sun sweeps over equal areas in equal times.

Items 294 - 303. After each item number on the answer sheet, blacken space

A if the observation is explained more simply by the heliocentric theory.
B if the observation is explained more simply by the geocentric theory.
C if the observation is explained by either theory.
D if the observation is explained by neither theory.

294. (1.30) The diurnal motion of the sun and stars.

295. (1.30) The phases of Venus and Mercury.

296. (1.30) The retrograde motion of the planets.

297. (1.30) The eastward motion of the sun among the stars.

298. (1.30) The annual parallactic displacement of the stars.

299. (1.30) The earth has only one satellite.

300. (1.30) The moon's period of rotation is equal to that of revolution.

301. (1.30) Orbits of the planets are ellipses with the sun at one focus.

302. (1.30) The sun rises in the east.

303. (1.30) The lunar phase.

Items 304 - 315. After each number on the answer sheet, blacken space

A if the phenomenon is caused by the rotation of the earth of its axis.
B if the phenomenon is caused by the revolution of the earth about the sun.
C if the phenomenon is due to the inclination of the earth's axis.

D if the phenomenon is due to a combination of the revolution of the earth about the sun and the inclination of the earth's axis.

E if the phenomenon is due to the somewhat flattened, but essentially spherical shape of the earth.

304. (1.30) The changing plane of swing of the Foucault pendulum.

305. (1.30) Variation in altitude of the Polar Star with changing latitude.

306. (1.30) Apparent eastward motion of the sun among the stars.

307. (1.30) The increasing area of the earth which becomes visible as one ascends in a balloon.

308. (1.30) The succession of day and night.

309. (1.30) The succession of the seasons.

310. (1.30) Variation in the length of day and night during the year (except at the equator).

311. (1.30) The apparent back-and-forth motion of the near stars with respect to the more distant ones.

312. (1.30) The westward motion of the polar winds.

313. (1.30) Change in angle at which the sun's rays fall on Chicago at noon on different days.

314. (1.30) The variation in the force of gravity with latitude.

315. (1.30) The progressive disappearance of a ship's smokestack as the ship puts out to sea.

Items 316 - 319 deleted.

320. (1.30) It is to be expected that, when a given planet displays retrograde motion, the planet's distance from the sun in the sky will be

A. more than 90°, whether the planet's orbit falls within the earth's or vice-versa.
B. less than 90°, whether the planet's orbit falls within the earth's or vice-versa.
C. more than 90°, if the planet's orbit falls within the earth's, less than 90° if the earth's orbit falls within the planet's.
D. less than 90° if the planet's orbit falls within the earth's, more than 90° if the earth's orbit falls within the planet's.
E. more than 90°, and that the earth's orbit must fall within the planet's.

321. (1.30) The direct significance of Kepler's Laws of Areas for Newton's theory of the solar system is that it gives a definite indication concerning

A. the variation of the force acting on a planet, with the distance of the planet from the sun.
B. the variation of the mass of a planet as its position changes.
C. the position in the solar system of the center of the forces of attraction which hold the planets in their orbits.
D. the dependence of the force acting on a planet or satellite upon the mass of the attracting body.
E. none of the above.

322. (1.30) The absence of any considerable motion of the apsides of planetary orbits is *direct* evidence for which of the following propositions, according to Newton's theory of the solar system?

A. The acceleration of any one planet varies inversely as the square of its distance from the sun.
B. The accelerations of any two planets are to another inversely as the squares of their distances from the sun.
C. The accelerations of the planets are directed toward the sun.
D. The acceleration of any body, due to gravitational attraction, is proportional to the mass of the attracting body.
E. Jupiter and Saturn disturb one another's motions when they are in conjunction.

323. (1.30) Kepler's Third, or Harmonic, Law is used by Newton to determine

A. the relation of a planet's period to its mass.
B. the relation of a planet's acceleration to its mass.
C. the relation of the ratio of two planets' accelerations to their distances from the sun.
D. the relation of the ratio of one planet's accelerations at two different times to the distances from the sun at those times.
E. the relation of the ratio of two planets' masses, to their distances from the sun.

324. (1.30) The conclusion that the force acting on a planet or satellite varies inversely with the square of its distance from the attracting body, is based upon (*One* or *two* correct answers)

A. Kepler's first two Laws (Law of Ellipses and Law of Areas).
B. Kepler's Third Law (Harmonic Law).
C. the observation that the orbits of the satellites of planets are practically circular.
D. each of the above three results; i.e., each *by itself* provides evidence for the conclusion.
E. all three of the above results taken together, although it is not justified by any one of them individually.

325. (1.30) The principal significance of the moon, in Newton's construction of his theory of the solar system, is that it provides a means of establishing

A. Kepler's Law of Areas.
B. the inverse square law.
C. the equality of action and reaction in the solar system.
D. the proportionality of weight and mass.
E. the connection of astronomical forces with the terrestrial phenomenon of gravity or weight.

326. (1.30) Which of the following does *not* provide evidence for the conclusion that the motive force of gravity is proportional to the mass of the body acted upon?

A. A large and a small body, dropped simultaneously from a high tower, hit the ground nearly simultaneously.
B. The period of oscillation of a pendulum depends only on its length, not on its mass.
C. The squares of the periods of the planets are proportional to the cubes of their distances from the sun.

D. The squares of the periods of Jupiter's satellites are proportional to the cubes of their distances from Jupiter.

E. The apsides of the moon's orbit move forward only about 3° per month.

327. (2.1) Two circles are concentric if they have the same center and are in the same plane, but have different radii. An example of this is the

A. orbit of the earth and the ecliptic.
B. equator of the earth and the celestial equator.
C. any two meridian circles.
D. Tropic of Cancer and the Tropic of Capricorn.
E. circumference of the sun and the orbit of the earth.

Items 328 - 331 are to be answered by reference to the following excerpt from *Fundamentals of Physical Science* by Konrad Krauskopf.

By the sixteenth century it had become obvious that something was not quite right in the Ptolemaic system. Observed positions of the planets simply did not agree with the positions calculated from Ptolemy's complicated orbits. Discrepancies were not large, but could be detected even by inexpert observers. There were two possible ways for removing the discrepancies; either slight changes could be introduced into the Ptolemaic orbits,—or the Ptolemaic hypothesis could be discarded in favor of a completely new hypothesis based on different assumptions.

328. (2.10) The Ptolemaic system mentioned in the quotation refers to

A. a system of numbers that preceded Roman numerals.
B. a theory of geometry developed in Egypt.
C. an attempt to depict interstellar relationships.
D. an explanation to account for movement of heavenly bodies.

329. (6.00) Discrepancies between calculated and observed positions were

A. of real significance because the former were theoretical while the latter were factual.
B. of no significance because they were detected by inexpert observers.
C. to be expected because the orbits were so complicated.
D. of no particular interest because they were so small.

330. (1.30) If slight changes had been introduced into the Ptolemaic orbits it would have

A. been unfair to Ptolemy.
B. offered a simple solution to the problem.
C. made the system still more complicated.
D. been a forward step in astronomy.

331. (1.10) A completely new hypothesis based on different assumptions would be preferred if

A. only one fact was not explained by the old hypothesis.
B. only one fact contradicted the assumptions on which the old hypothesis was based.
C. further assumptions were found to be necessary to support the old hypothesis.
D. someone had developed a new hypothesis that required fewer assumptions.

332. (2.10) The distance from the sun to the earth is one astronomical unit and from the sun to Jupiter is 5.20 astronomical units. The earth takes one year to go around the sun. Using the formula

$\frac{a_1^3}{a_2^3} = \frac{p_1^2}{p_2^2}$ a equals distance from the sun.
p equals the time of one revolution of the planet.

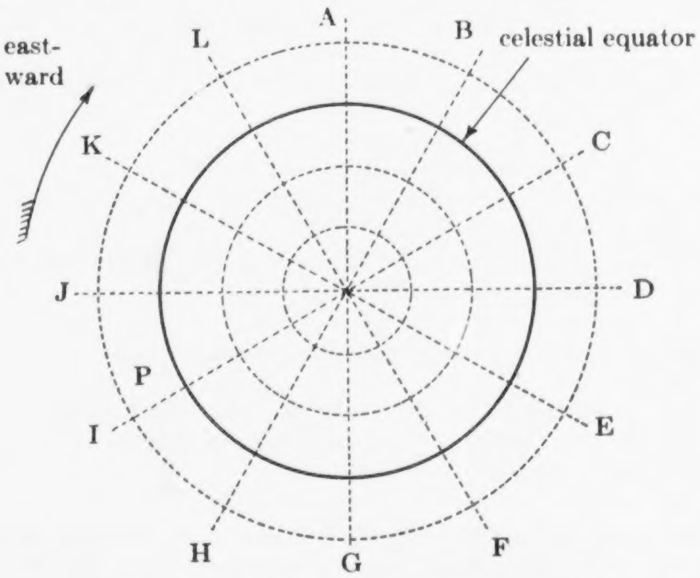
determine the time in years that it takes Jupiter to go once around the sun.

A. 11.8. **B.** 5.23. **C.** 13.30. **D.** 20.86.
E. 14.02.

333. (1.30) The preceding question is a direct application of

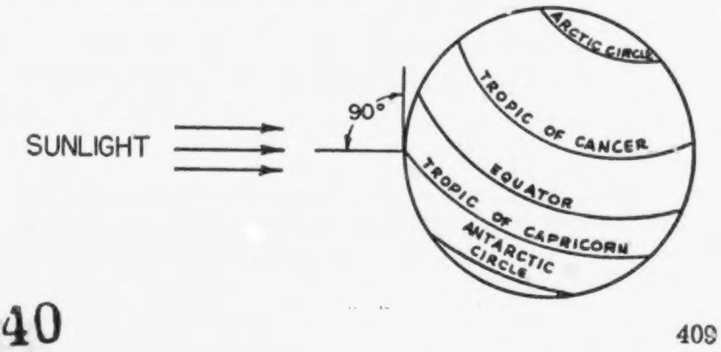
A. Newton's first Law. **B.** Kepler's first Law.
C. Dalton's Law. **D.** Newton's third Law.
E. Kepler's third Law.

Item 334.



The above diagram is a planisphere representation of the celestial sphere as seen by looking up at the north celestial pole. The vernal equinox is on radius A where it intersects the celestial equator. Refer to the diagram above.

a. (2.10) Plot the position of the vernal equinox and label it V.
b. (2.10) Plot the position of the sun on June 21 and label it X.
c. (2.10) Plot the position of the sun on September 21 and label it Y.
d. (2.10) The star Antares is located at the point P on the diagram. Its right ascension is________, and its declination is________.
e. (3.00) On March 19, 1954, there was a full moon. The moon was nearest to radius________. Why?
f. (3.00) The next full moon (after March 19) will be nearest to radius________. Why?
g. (3.00) If a bright planet were seen at the end of September on radius D, could it be Venus? ________. Why?



Items 335 - 344. Blacken the space after each exercise number corresponding to the correct answer.

335. (2.10) In the northern hemisphere it is the beginning of

A. spring. **B.** summer. **C.** autumn. **D.** winter.

336. (2.10) At noon, the sun's rays are perpendicular to

A. the equator. **B.** the Tropic of Cancer.
C. the Tropic of Capricorn.
D. the Antarctic Circle.
E. two or more of the preceding items.

337. (2.10) At this position the earth is

A. at its closest distance to the sun.
B. at its greatest distance from the sun.
C. at its average distance from the sun.
D. just beyond its greatest distance from the sun.
E. just beyond its closest distance from the sun.

338. (2.10) The entire region in complete darkness for at least one day is that

A. between the equator and the Tropic of Cancer.
B. between the Tropic of Capricorn and the Antarctic Circle.
C. at the equator. **D.** north of the Arctic Circle.
E. south of the Antarctic circle.

339. (2.10) Lengths of daylight and darkness are equal at

A. the Arctic Circle. **B.** the Tropic of Cancer.
C. the equator. **D.** the Tropic of Capricon.
E. all points on the earth.

340. (2.10) One week later than that shown in the diagram the period of daylight in the northern hemisphere will be

A. longer. **B.** shorter. **C.** the same.

341. (2.10) The time indicated is

A. the summer solstice. **B.** the winter solstice.
C. the vernal equinox. **D.** the autumnal equinox.
E. none of the preceding.

342. (2.1) The sun can be seen at midnight at

A. the equator. **B.** the Tropic of Capricorn.
C. 47°S. **D.** 75°S. **E.** all southern latitudes.

343. (2.10) At the Tropic of Capricorn the altitude of the noon sun is

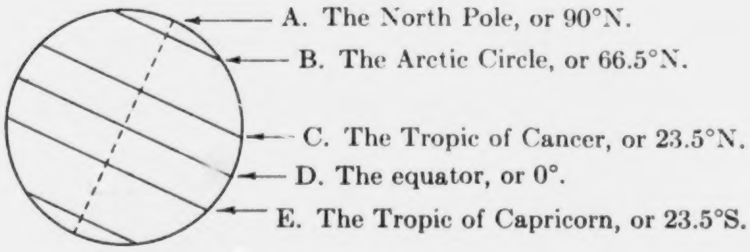
A. 0°. **B.** 23.5°. **C.** 47°. **D.** 75°. **E.** 90°.

344. (2.10) To observers in the southern hemisphere the length of daylight is of

A. maximum duration. **B.** minimum duration.
C. a value between its maximum and minimum duration.

Items 345 - 362.

The following diagram shows five different locations on the surface of the earth. After each item number on the answer sheet, blacken the *one* lettered space to designate the location for which the item is true.


A. The North Pole, or 90°N.
B. The Arctic Circle, or 66.5°N.
C. The Tropic of Cancer, or 23.5°N.
D. The equator, or 0°.
E. The Tropic of Capricorn, or 23.5°S.

345. (2.10) This location is farther from the center of the earth than any of the others.

346. (2.10) A person in this location can move in only one direction on the earth's surface.

347. (2.10) In this location the plane of swing of a Foucault pendulum would apparently make a complete turn in twenty-four hours.

348. (2.10) When the sun is overhead at this location, the earth is near the perihelion point in its orbit.

349. (2.10) When the sun is overhead in this location, every place on earth has days and nights of equal length.

350. (2.10) All of the stars may be seen from this location, at one time or another.

351. (2.10) When the sun is at the zenith in this location, it appears to be at the intersection of the ecliptic and the celestial equator.

352. (2.10) This location is at the boundary of the "land of the midnight sun."

353. (2.10) Here, all year long, there are almost twelve hours of light and twelve hours of darkness every day.

354. (2.10) September 22 is the last day of six months of daylight in this location.

355. (2.10) To an observer in this location the stars appear to move in concentric circles about the zenith.

356. (2.10) In this location the sun never sets on June 21, although it touches the horizon for a moment.

357. (2.10) When observed from this location, the altitude of the North Star is 23.5°.

358. (2.10) Twice during the year the sun is at the zenith for an observer in this location.

359. (2.10) In this location, at the winter solstice the sun appears on the horizon for a moment and then disappears.

360. (2.10) For an observer in this location, the sun is directly overhead at noon on the vernal equinox.

361. (2.10) The North Star can never be seen from this location.

362. (2.10) At noon on December 22, the sun is at the zenith for an observer in this location.

363. (2.20) The earth turns on its axis once in 24 hours. The moon revolves around the earth once in 27.3 days and in the same direction that the earth turns. The moon

A. rises earlier each night. **B.** rises later each night.
C. rises the same time each night.
D. The problem cannot be solved with the data presented.

Items 364 - 368 involve certain theoretical statements. For each item select from the key the response most closely related to it.

KEY

A. The earth rotates on the axis W to E.
B. The earth revolves around the sun.
C. The orbit of the earth is an ellipse with the sun at one focus.
D. The axis of the earth is inclined 23½ degrees with the vertical.
E. None of these.

364. The apparent size of the sun varies during the year.
(2.40)

365. The relative motion of one star with another has been observed.
(2.40)

366. The gravitation pull of the earth is greatest at the poles.
(2.40)

367. The seasons vary in their average temperatures.
(2.40)

368. Storms and air masses generally travel in the same direction in Michigan.
(2.40)

369. If the moon were to revolve around the earth twice instead of once in 27⅓ days,
(2.30)

A. its mass would have to be greater if its distance to the earth were to remain the same.
B. its distance to the earth would be unchanged if its mass were unchanged.
C. its mass would have to be less if its distance to the earth were to remain the same.
D. its distance to the earth would be less if the mass were the same.
E. none of the above statements are correct.

For each item 370 - 377 select from the key the response that represents the cause of what is described in the item.

KEY

A. The earth is not quite spherical.
B. The earth rotates on its axis.
C. the earth revolves around the sun.
D. The axis of the earth is inclined 66½° with respect to the plane of its orbit.
E. Two of the above.

370. On the earth, the acceleration of gravity is greatest at the poles.
(2.40)

371. The relative motion of one star with respect to another has been observed.
(2.40)

372. Photographs of stars near the Pole Star appear as concentric circles.
(2.40)

373. The seasons vary in their average temperatures.
(2.40)

374. A Foucault pendulum does not follow the trace of a line on which it is started.
(2.40)

375. Michigan lies in the westerly wind belt.
(2.40)

376. Summer days are longer than summer nights in the United States.
(2.40)

377. Constellations of the zodiac appear different in an October sky from those in a December sky.
(2.40)

378. One should expect a total eclipse of the moon each month (lunar month), that is, the moon should enter the shadow cast by the earth. Actually there are more eclipses of the sun annually than there are of the moon. The best explanation of this is the fact that
(2.20)

A. the earth's orbit is not a perfect circle.
B. the shadow cast by the earth is usually too short to blot out the moon.
C. the moon's orbit is inclined in respect to the earth's orbit.
D. the moon is too close to the earth.
E. the moon moves in a given direction more rapidly than does the earth.

379. The average temperature of a given point on the earth's surface depends on the season of the year. Which one of the following gives the best explanation of this phenomenon?
(2.20)

A. Variations in the distance of the earth from the sun.
B. Variations in the speed of the earth in its orbit.
C. Inclination of the earth's axis with respect to the plane of the ecliptic.
D. Variations in the sun's brightness.
E. Variations in the number of sunspots.

380. How do you best account for the fact that the plane of swing of a Foucault pendulum has no apparent rotation at the equator, while it appears to rotate 360° in 24 hours at either of the poles?
(2.20)

A. The force of gravity is greater at the poles than at the equator.
B. The earth rotates on its axis once in every 24 hours.
C. At the poles the earth rotates on its axis while at the equator it does not.
D. Except at the equator, the surface of the earth turns with respect to the unchanging plane of swing.
E. The axis of the earth has a gyratory motion.

381. The longitude of a point on the earth's surface may be determined by
(1.10)

A. comparing time at the location of the point with Greenwich time.
B. measuring the parallax of the sun.
C. measuring the apparent angular diameter of the moon.
D. measuring the altitude of Polaris.
E. determining the sidereal time of the meridional transit of the North Celestial Pole.

382. Near the equator, the earth rotates about 1000 miles per hour. If the speed were reduced to 200 miles per hour,
(2.30)

A. airplanes flying W to E would be able to fly much faster.
B. the seasons would be of shorter duration.
C. our weight would be affected slightly.
D. the earth's atmosphere would float into outer space
E. the force of gravity would be lessened.

383. If some external force should shift the earth nearer the sun so that the mean radius of its orbit would be 80,000,000 miles, the anticipated effect on the earth would cause all of the following *except*
(2.30)

A. seasons to be shorter.
B. sidereal (star) day to be longer.
C. average yearly temperature to be higher.
D. year to be shorter. **E.** orbital speed to be greater.

384. If the earth's mass were increased but its diameter re-
(2.30) mained unchanged, the period of revolution of the moon around the earth would

A. necessarily increase. **B.** necessarily decrease.
C. remain the same. **D.** be entirely unpredictable.
E. not be the same as the period of rotation of the moon.

385. If the tropical year were equal to 365.101 mean solar
(2.30) days, leap years would be necessary

A. every other year. **B.** every four years.
C. every ten years. **D.** every hundred years.
E. No leap years would be necessary.

386. A star is seen on the meridian at 10 P.M. At 11 P.M.
(2.30) the same night the star is

A. east of the meridian by about 4°.
B. east of the meridian by about 15°.
C. approximately on the meridian.
D. west of the meridian by about 4°.
E. west of the meridian by about 15°.

387. If the mass of the earth were ½ its present value and its
(2.3) distance from the sun the same as it is now, the period of revolution of the earth around the sun would be

A. the same as it is now. **B.** doubled. **C.** halved.
D. increased by some factor other than 2.
E. unpredictable.

Items 388 - 390. The following observations have been made.

A. Some stars appear to move slightly during the year with reference to the background of other stars.
B. The plane in which a pendulum swings appears to change with respect to the ground.
C. The regular diameter of the sun changes thoughout the year.
D. The zenith distance of the North Celestial Pole is approximately proportional to the distance of the place from the North Pole of the earth.

Each of the following statements is based on one of these observations. Blacken the space corresponding to the observation upon which the item is based.

388. The earth rotates on its axis.
(2.40)

389. The earth is approximately spherical in shape.
(2.40)

390. The shape of the earth's orbit is an ellipse.
(2.40)

391. Kepler stated three Laws of Planetary Motion. Which
(2.40) one of the following statements is related to one of his laws?

A. Planets increase in size in the same order as their distance away from the sun.
B. The larger the planet, the longer the time required for one complete rotation.
C. A planet twice as far from the sun as the earth would have a year twice as long as ours.
D. The earth is traveling in its orbit at a speed different in January from that in July.
E. All planets have a year which is the same length as ours.

Answer items 392 - 398 by reference to this key:

KEY

A. Every planet moves in an elliptical orbit around the sun which occupies one focus of the ellipse.
B. The line connecting a planet with the sun sweeps over equal areas in equal time.
C. The squares of the times required for the different planets to move completely around the sun are proportional to the cubes of their distance from the sun.
D. The axis of the earth is tilted 66½° with respect to the ecliptic.
E. Two of the above.

392. The earth is nearer to the sun in winter than in summer.
(2.40)

393. The major cause for the mean temperature in East
(2.40) Lansing being higher in July than in January.

394. The earth travels a greater distance in its orbit on
(2.40) January 1 than on July 1.

395. Twice during the year day and night are equal in length
(2.40) everywhere on the earth.

396. One year on the earth is about 365 days but one year
(2.40) on Mercury is about 88 days.

397. The speed of the earth as it revolves in its orbit about
(2.40) the sun is not uniform.

398. If the length of years of the earth and another planet
(2.40) are known, the distance from the sun to the other planet in astronomical units can be calculated.

399. An aviator flies from New York to Chicago, Illinois,
(3.00) consuming 8 hours in the journey. If he leaves New York at 11:00 A.M. (Eastern Standard Time) on May 7, at what time (Central Standard Time) will he arrive in Chicago?

A. 6:00 P.M. May 7. **B.** 7:00 P.M. May 7.
C. 8:00 P.M. May 7. **D.** 9:00 P.M. May 7.
E. 5:00 P.M. May 7.

400. In the Mountain Standard Time Zone, the clocks, com-
(1.10) pared with those on Standard Time in Chicago

A. are one hour behind. **B.** are one hour ahead.
C. show the same time.

401. This situation results from the fact that the center of
(1.10) the Mountain Standard Time Zone is ________ of longitude west of the center of the Central Standard Time Zone.

A. 7½°. **B.** 15°. **C.** 22½°. **D.** 23½°. **E.** 30°.

402. "The sun now rose upon the right
(3.00) Out of the sea came he,
Still hid in mist, and on the left
Went down into the sea.

And the good south wind still blew behind,"

The Ancient Mariner was sailing

A. north in the trade winds north of the equator.
B. south in the trades south of the equator.
C. on the equator about the middle of March.
D. south in the trades north of the equator.
E. north in the trades south of the equator.

403. "All in a hot and copper sky
(3.00) The bloody sun, at noon
Right up above the mast did stand,
No bigger than the moon."

The Ancient Mariner at this time could have been on the

A. equator in June.
B. tropic of Capricorn (23½ degrees S) in June.
C. tropic of Cancer in March.
D. equator in September.
E. tropic of Cancer in September.

Items 404 - 410.

A new and simple method for plotting the distance to a just-discovered asteroid has been suggested by Dr. John S. Hall and Arthur A. Hoag of the U. S. Naval Observatory. The proposed method consists of measuring the amount of polarization in the light from the asteroid. When light is polarized, its rays are not at random but have been altered so that their vibrations have a preferred direction. Polaroid film is used for sunglasses to cut down glare. A piece of polaroid will let through light vibrating in only one plane, just as a directional antenna preferentially receives certain radio waves. Automobile engineers have shown that the light from headlamps of automobiles is partially polarized by reflection from the road surface.

From observations of the Moon, Mars, and Mercury, it is known that the polarization value changes quite markedly with the angle of vision. That is, this value varies with the angle between the earth and the sun as seen from the object. Following the suggestion of Dr. Hall and Mr. Hoag, astronomers will try to determine this relationship for some minor planets. They will do so by finding the relationship between the amount of polarization and the angle of vision. When the polarization of an unknown object is observed, astronomers can then determine the angle of vision from this relationship.

When this angle is known, the solution of the distance problem is simple. This is because the angle formed at the earth by the sun and by the asteroid, and the distance to the sun are both known. That is, two angles and one side of a triangle are known, and the distance to the unknown object can be readily determined. (Science Service.)

In using the process described to determine the distance to a newly discovered asteroid, the following procedure could be followed:

A. Obtain complete data for the planet Mercury.
B. Check the results of the data for Mercury by observations on the Moon and Mars.
C. If the process seems valid, apply it to the asteroid to determine its distance from the earth.

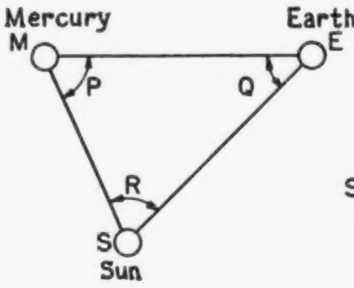


Figure 1.

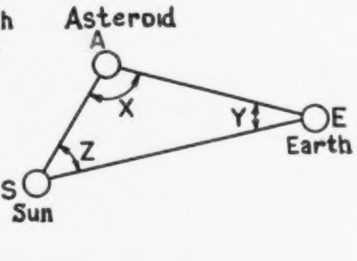


Figure 2.

Items 404 - 410 are to be answered by reference to the article and diagrams.

404. (3.00) The relation between the amount of polarization and the angle of vision P (see Figure 1) is determined for Mercury since

A. Mercury is an inner planet.
B. Mercury is close to the sun and reflects a great deal of light.
C. its orbit is well established and all parts of the triangle EMS are readily computed from this knowledge.
D. its periods of rotation and revolution are equal.
E. Mercury has a relatively small diameter and behaves as a point more effectively than any of the other planets.

405. (3.00) After all data has been collected for several values of P in the triangle EMS, the angle P is then expressed in terms of the

A. earth-sun distance. **B.** angle Q.
C. amount of the sun's light reflected to the earth by Mercury.
D. mean distance of Mercury from the sun.
E. amount of polarization in the light received from the planet Mercury.

406. (3.00) Similar data is collected for the Moon and for the planet Mars. If the process is one of universal application, which of the following must be true?

A. The angle P must vary directly as the amount of polarization.
B. The relation between the angle P and the amount of polarization must be such that a mathematical formula exists relating them.
C. The angle P must have the same range of values for Mercury, the Moon, and Mars.
D. The amount of polarization of the light from each must be the same for all common values of P.

407. (3.00) In using this method to find the distance to an asteroid, which of the parts of the triangle EAS (see Figure 2) is determined by direct observation?

A. Angle Y. **B.** Angle X.
C. Earth-asteroid distance. **D.** Earth-sun distance.
E. Sun-Asteroid distance.

408. (3.00) In using this method to find the distance to an asteroid, which of the parts of the triangle EAS (Figure 2) is determined directly from the amount of polarization?

A. Angle Y. **B.** Angle X. **C.** Earth-sun distance.
D. Earth-asteroid distance. **E.** Sun-asteroid distance.

409. (3.00) This method, together with the results of the observations on Mercury, Mars, and the Moon, corresponds most closely to the laboratory technique of

A. direct measurement of desired phenomena.
B. design and calibration of a new instrument for measuring a desired phenomena.
C. correctly recording data.
D. always conducting preliminary experiments before attempting the principal one.

410. (3.00) The method is not applicable to the determination of distances to stars since

A. the distance from the earth to the stars is too great to permit accurate measurement.
B. the stars do not change position.
C. the stars shine by emission of light, not by reflection of light.
D. the angle of vision of stars is too small to permit accurate measurement.

Items 411 - 416. Consider this hypothetical situation:

Assume that the earth's axis were at right angles with the plane of its orbit rather than at 66½° as at present, and that the orbit of the earth around the sun remains unchanged.

For each item select from the key the most appropriate response.

KEY

A. The statement is true. **B.** The statement is false.
C. Additional information would be necessary to answer the item.

411. (3.00) The earth would be flattened at the equator instead of at the poles.

412. (3.00) The climate at 40° north latitude and at 40° south latitude would be the same.

413. (3.00) In December when we are about 3,000,000 miles closer to the sun than in June, we could expect slightly warmer weather than in June.

414. (3.00) Rainfall in Michigan would increase considerably.

415. (3.00) The area of the earth's surface receiving sunlight would be greater.

416. (3.00) The seasons in Michigan would be similar to what they are now.

417. (3.00) Suppose that the earth's axis of rotation were parallel to the plane of its orbit but maintained a fixed direction in space. What, if any, change in the seasons would be observed at the North Pole?

A. A very hot season lasting for 6 months would change abruptly to a very cold season for the remainder of the year.
B. The temperature would change gradually from a high maximum to a very low minimum 6 months later.
C. The temperature would remain moderate throughout the year.
D. The temperature would remain very low at all times.
E. The temperature would remain very high at all times.

Items 418 - 427 refer to the changes which would occur if the observation were made on the moon instead of the earth. For each item select from the key the most appropriate response.

KEY

A. The quantity is constant, but not zero.
B. The quantity increases.
C. The quantity becomes zero.
D. The quantity decreases.
E. No prediction can be made without additional data.

418. (3.00) The velocity of electromagnetic radiation.

419. (3.00) The apparent weight of a large rubber balloon inflated for level flight on earth.

420. (3.00) The boiling temperature of a beaker of water.

421. (3.00) The gravitational force between the moon and the earth.

422. (3.00) The distance from the sun.

423. (3.00) The velocity of sound above the solid surface.

424. (3.00) The weight of a ton of coal.

425. (3.00) The index of refraction of glass.

426. (3.00) The "weight" obtained for 1 lb. of gold on a laboratory beam balance.

427. (3.00) The rate of combustion of fuel oil.

428. (3.00) When it is noon in Greenwich, England, in New York (longitude 75°W.) it is

A. 5:00 A.M. **B.** 5:00 P.M. **C.** 7:00 A.M.
D. 7:00 P.M. **E.** None of these.

429. "The lights begin to twinkle from the rocks;
The long day wanes; the slow moon climbs; the deep
Moans round with many voices........"
Tennyson's *Ulysses.*

The moon referred to is

A. new. **B.** first quarter. **C.** full.
D. last quarter.

430. (3.00) A rocket ship is traveling around the earth at the equator. The pilot observes that although his watch has stopped it continues to keep approximately correct solar time. This would be true if he were flying,

A. east at about 1000 miles per hour.
B. west at about 1000 miles per hour.
C. east at about 25,000 miles per hour.
D. west at about 25,000 miles per hour.

431. (1.10) The sidereal day is measured by

A. the interval between two successive transits of the center of the sun across the celestial meridian.
B. the time required for one rotation of the earth as measured with respect to the sun.
C. the time required for one rotation of the earth as measured by the moon.
D. the interval between two successive transits of a certain star across the meridian.
E. none of the above.

432. (3.00) A traveler observes that the altitude of a certain star has remained constant throughout his trip. From this fact alone he can definitely conclude that

A. he has been traveling east.
B. he has been traveling west.
C. his latitude has not changed.
D. his longitude has not changed.

433. (3.00) At the Autumnal equinox the

A. sun appears on the celestial equator.
B. sun never sets at 66.5°N. latitude.
C. earth is at aphelion.
D. length of day and night are the same only at the equator.

434. On June 21st, the sun will be at the zenith at noon for
(3.00) all observers to see at

A. 66.5°S. latitude. **B.** 23.5°S. latitude.
C. 23.5°N. latitude. **D.** 180°E. longitude.

435. Mechanical clocks were important when first invented
(1.10) because they

A. could tell accurately when moon occurred.
B. could be used to set up a calendar.
C. made it possible to determine longitude.
D. made it possible to break up the day into 24 hours.

436. During an eclipse of the moon, an observer has a unique
(1.1) opportunity to obtain evidence that the

A. moon is spherical. **B.** earth is moving.
C. sun is moving. **D.** earth is spherical.

437. Astronomers tell us that the earth is rotating on its axis
(1.24) at a speed of 1,000 miles per hour at the equator. We believe this partly because

A. we can feel that we are moving.
B. there would be no movement of the air if there was no rotation.
C. daily motions of other heavenly bodies are simpler to explain.
D. it is the only easy way to explain night and day.

438. It is claimed that the earth is closest to the sun on or
(1.24) about January 4th.

A. The statement is not true.
B. If the statement were true, January should be our warmest month.
C. Photographs show the sun to be larger in winter than in summer.
D. The distance between the earth and the sun never changes.

439. Actual proof that the earth moves through space was
(1.10) best obtained after the development of the

A. sun dial. **B.** telescope. **C.** sextant.
D. mechanical clock.

440. At two o'clock in the morning of April 19, 1775, Paul
(3.00) Revere was captured by a British patrol on the road between Lexington and Concord. They saw him coming along by light from the moon in the eastern sky. It is evident from the above that the moon was

A. a new moon. **B.** at first quarter.
C. a full moon. **D.** at last quarter.
E. at eastern quadrature.

441. A total eclipse of the sun would occur once each month,
(3.00) if the

A. axis of the earth was perpendicular to the plane of the moon's orbit.
B. moon's orbit coincided with the plane of the ecliptic.
C. synodic month equaled the sidereal month.
D. moon's orbit coincided with the plane of the celestial equator.
E. actual path of the moon about the sun differed more than it does now from the orbit of the earth.

442. The moon rises about 51 minutes later each day. Its
(1.10) later rising is due to the

A. rotation of the earth on its axis.
B. rotation of the moon on its axis.
C. inclination of the axis of the moon to the orbit of the earth.
D. revolution of the moon in its orbit.
E. revolution of the earth in its orbit.

443. Suppose that men in a space ship are able to land on
(3.00) the moon when it is a new moon and on the side toward the earth. Which of the following would be true?

A. The earth would appear like a very large full moon.
B. The moon's surface around their landing place would be in bright sunlight.
C. The earth would appear faintly illuminated by moonlight.
D. The earth would look like a very large half moon.
E. The moon's surface around their landing place would be completely dark.

444. Lunar eclipses last longer than solar eclipses and may be
(3.00) seen from all points on the earth's surface from which the moon can be seen, because the

A. sun, earth, and moon need not be in the same, or nearly the same, straight line.
B. moonlight rather than the sunlight is shut off by the eclipse so far as an observer on earth is concerned.
C. moon is farther from the sun and is traveling more slowly.
D. apparent size of the moon is about the same as the apparent size of the sun.
E. earth casts a larger shadow than the moon.

Items 445 - 451, refer to observations made at sea level. Select from the key the change which would occur if these were made at the surface of the moon.

KEY

A. Increase. **B.** Decrease. **C.** Remain unchanged.
D. Become zero or inoperative.
E. No basis for predictions.

445. The velocity of light.
(3.00)

446. The presence of sedimentary rock.
(3.00)

447. The mass of a rocket plane.
(3.00)

448. The diurnal variation of temperature.
(3.00)

449. The application of Coulomb's Law of electric charges.
(3.00)

450. The combustion of wood.
(3.00)

451. Barometric pressure.
(3.00)

452. At the latitude of New York or Chicago (about 42 de-
(3.00) grees), the altitude of the sun in the sky at noon, with the change in seasons, may have a maximum range from

A. 0 degrees to 90 degree.
B. 25 degrees to 70 degrees.
C. 0 degrees to 25 degrees.
D. 30 degrees to 48 degrees.
E. 10 degrees to 23½ degrees.

453. At the latitude of Lansing, the maximum altitude reached by the sun at noon at anytime during the year is about
(3.00)

A. 0 degrees. **B.** 23½ degrees. **C.** 45 degrees.
D. 70 degrees. **E.** 90 degrees.

Items 454 - 461.

You have acquired some knowledge of the earth and its motions as they really exist. In this exercise you are to identify the effects of some wholly imaginary conditions. After each item number on the answer sheet, blacken space

A if the item would be true if the earth were *not* inclined on its axis.
B if the item would be true if the orbit of the earth was a circle rather than an ellipse.
C if the item would be true if the earth rotated toward the west rather than toward the east.
D if the item would be true if the earth had half its present diameter but retained its present mass.
E if the item would be true if the earth had no moon. (Assume only one of the above imaginary conditions occurs at a time)

454. Objects would weigh four times as much as they do now.
(3.00)

455. The celestial equator and the ecliptic would be identical.
(3.00)

456. The sun would set in the east.
(3.00)

457. A different North Star would need to be chosen.
(3.00)

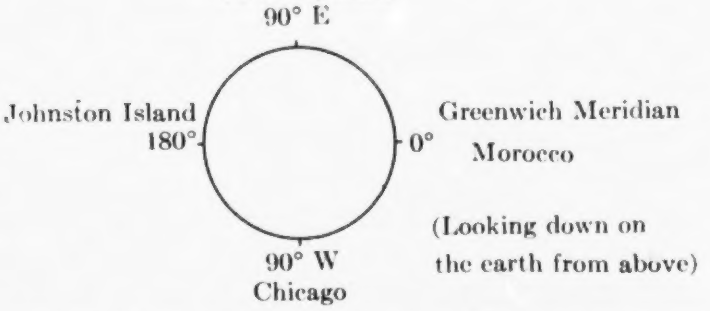
458. The force of gravity would be four times as great.
(3.00)

459. The orbital speed of the earth would not vary during the year.
(3.00)

460. There would be no tides as now occur.
(3.00)

461. Night and day would be of equal length in all latitudes all year long.
(3.00)

Items 462 - 465.



In conducting an experiment, the United States Air Force had two B-56 bombers take off from Calcutta, India, flying non-stop to Chicago, Illinois. One plane flew in an easterly direction, the other flew to Chicago by going west. Both planes were to be refueled in the air, the east-flying plane near Johnston Island, which is approximately on the international date line, and the west-flying plane over Morocco just past the Greenwich Meridian. Both planes flew the same distance, 12,000 miles, averaging a ground speed of 300 mph.

462. The total time each plane was in the air was:
(3.00)

A. 40 hours for the west-flying plane, 64 hours for the east-flying plane.
B. 40 hours for the west-flying plane, 16 hours for the east-flying plane.
C. 40 hours for each plane.
D. 40 hours for the east-flying plane, 64 hours for the west-flying plane.
E. 40 hours for the east-flying plane, 16 hours for the west-flying plane.

463. If both planes took off from Calcutta at noon on Thursday, November 5 (Calcutta time), and flew the 6000 miles to where they were to be refueled, their respective arrival time would be
(3.00)

A. 8 A.M. Friday, Johnston time; 2 A.M. Friday, Morocco time.
B. 2 A.M. Thursday, Johnston time; 2 A.M. Friday, Morocco time.
C. 2 P.M. Wednesday, Johnston time; 2 A.M. Saturday, Morocco time.
D. 2 A.M. Friday, Johnston time; 2 A.M. Friday, Morocco time.
E. 2 P.M. Thursday, Johnston time; 2 A.M. Friday, Morocco time.

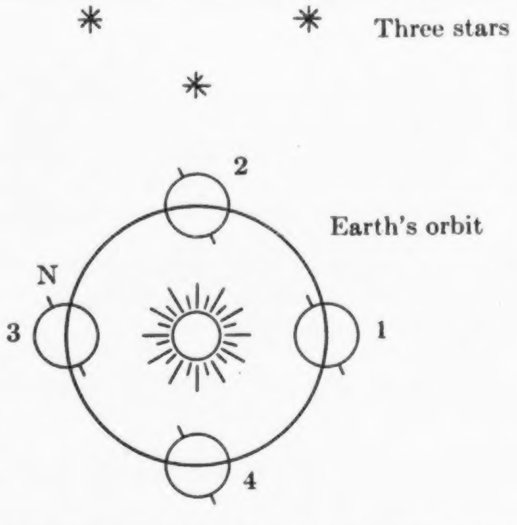
464. Arrival time in Chicago (local time) for the two planes would be:
(3.00)

A. the same.
B. one day earlier for the plane crossing the date line.
C. one day later for the plane crossing the date line.
D. 12 hours earlier for the plane crossing the date line.
E. 12 hours later for the plane crossing the date line.

465. Arrival time in Chicago (local time) would be
(3.00)

A. 4 P.M. Friday for both planes.
B. 4 P.M. Friday for the plane crossing the date line; 4 P.M. Saturday for the plane flying via Morocco.
C. 4 P.M. Saturday for the plane flying over the date line; 4 P.M. Friday for the plane flying via Morocco.
D. 4 P.M. Thursday for the plane flying over the date line; 4 P.M. Friday for the plane flying over Morocco.
E. 4 A.M. Friday, for the plane flying over the date line; 4 P.M. Friday for the plane flying over Morocco.

Items 466 - 470.



Above is a diagram of the earth at four positions in its orbital journey about the sun. At each of these positions a photograph of the group of three stars is made. Blacken lettered space

A. if the photograph shows ★ ★ ★
B. if the photograph shows ★ ★★
C. if the photograph shows ★★ ★

466. Photograph taken on June 21.
(3.00)

467. Photograph taken on March 21.
(3.00)

468. Appearance of the three stars in the photograph taken when the earth was farthest from the sun.
(3.00)

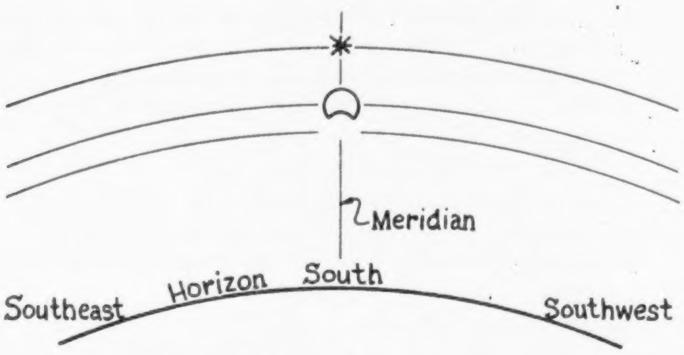
469. Photograph taken on the autumnal equinox.
(3.00)

470. Photograph taken when the earth was revolving at its maximum speed.
(3.00)

471. Such photographs are *most* useful as evidence that the
(3.00)

- **A.** orbital speed of the earth varies during the year.
- **B.** earth rotates on its axis.
- **C.** stars are at very great distances from the earth.
- **D.** earth revolves about the sun.
- **E.** distance to any very distant star can be determined by measuring its annual angular shift in direction as seen from the earth.

472. Suppose an observer at Hamilton faces south at 12 o'clock noon on a Monday and notes that the sun is partially eclipsed by the moon, and is on the meridian. With a telescope he also observes that a certain bright star is on the meridian at the same instant (noon) a few degrees above the sun. (See the diagram below. The approximate paths of the objects as they come to and leave the meridian are shown by dotted lines.)
(3.00)



a. The *next day,* Tuesday, when the *star* is on the meridian, the observer's clock would read (to the nearest minute)________.

b. On Tuesday, when the star is on the meridian, where would the sun be found? (Answer below in words, *also* mark the sun's position on the diagram, label it S.)

c. On Tuesday, when the star is on the meridian, where would the moon be found? (Answer below, also mark the moon's position on the diagram and label it M.)

d. On Tuesday the sun would cross the meridian at what time? ________.

e. On Tuesday the moon would cross the meridian at what time? ________.

f. On Tuesday will the path of the star as it comes to the meridian be identical with its path on Monday? YES NO (Circle one.)

g. What was the phase of the moon on Monday? (Underline your choice.)
(1) full (2) gibbous (3) half (4) crescent (5) new.

h. How long would it be before the moon and the star crossed the meridian at the same time or close to the same time again? ________.

i. How long would it be before the sun and the star crossed the meridian at the same or close to the same time again? ________.

j. How long would it be before the moon and the sun crossed the meridian at the same or close to the same time again? ________.

Items 473 and 474 are based on this situation. In a hypothetical solar system, a planet Q is twice as far from its sun as is a planet R. The mass of Q is twice that of R, although their radii are the same

473. The force exerted by the sun on the planet is
(3.00)

- **A.** ¼ as much on Q as on R.
- **B.** ½ as much on Q as on R.
- **C.** the same on Q as on R.
- **D.** 2 times as much on Q as on R.
- **E.** 4 times as much on Q as on R.

474. The acceleration of planet Q in its orbit is
(3.00)

- **A.** ¼ as much as that of R.
- **B.** ½ as much as that of R.
- **C.** the same as that of R. **D.** 2 times that of R.
- **E.** 4 times that of R.

A certain star is seen, by an observer in Chicago, just rising above the east point of the horizon at 6:00 p.m. on a certain day.

475. The observer should expect that, at 6:00 A.M. the following morning, the same star will be
(3.00)

- **A.** at the zenith.
- **B.** at a point on the meridian, south of the zenith.
- **C.** some distance above the west point of the horizon.
- **D.** just setting below the west point of the horizon.
- **E.** just rising again above the east point of the horizon.

476. The observer should expect that, at midnight on a day 9 months later, the same star will be
(3.00)

- **A.** below the horizon.
- **B.** at a point on the meridian, south of the zenith.
- **C.** some distance above the west point of the horizon.
- **D.** just setting below the west point of the horizon.
- **E.** just rising above the east point of the horizon.

477. The star referred to in questions 475 and 476
(3.00)

- **A.** must be on the celestial equator.
- **B.** must be on the ecliptic.
- **C.** must be several degrees north of the celestial equator.
- **D.** must lie between the celestial equator and the ecliptic.
- **E.** cannot be unambiguously assigned any of the above positions, on the basis of the information given.

478. From the universal gravitational equation, $F = \frac{Gm_1m_2}{r^2}$, and a knowledge of the radius of the moon's orbit and the acceleration of the moon in its orbital motion, one could calculate the mass of the earth, provided one knew
(3.00)

- **A.** the mass of the moon.
- **B.** the radius of the earth.
- **C.** the acceleration of a freely falling body on the moon's surface.
- **D.** the attractive force between two 1 gm masses placed 1 cm apart.
- **E.** the weight of a 1 gm mass.

479. Which of the following is a conclusion drawn by Newton in his discussion of the solar system, which should lead to new predictions concerning planetary motion, i.e., predictions which differ from those which would have been made before Newton elaborated his theory?
(3.00)

A. The forces on the planets are directed toward the sun.
B. The forces on the planets vary inversely with the squares of their distances from the sun.
C. The planets are attracted toward one another with forces great enough to produce an observable effect when two planets pass relatively close to one another.
D. The satellites of a planet are attracted toward the planet with forces that vary directly as their masses and inversely as the squares of their distances from the planet's center.
E. None of the above; since Newton's theory was based upon principles of planetary motion which were already known, it leads to no results at variance with those principles.

480. It can be computed which gases might be expected to be retained in a planetary atmosphere. Which of the following conditions would not have to be considered in such a computation?
(4.10)

A. The mass of the gas molecules.
B. The temperature of the planet.
C. The distance of the planet from the sun.
D. The mass of the planet.
E. The temperature of the gases.

481. If a planet has a satellite, the planet's mass can be found with greatest accuracy by equating the centripetal force of the satellite to the gravitational attraction between the planet and its satellite. Which of the following is not needed for the calculation?
(4.10)

A. The distance between the planet and the satellite.
B. The period of revolution of the satellite.
C. The mass of the satellite.
D. The gravitational constant.
E. All of the above are needed for the calculation.

482. Which of the following would be least helpful in explaining the total concept of a 24-hour day?
(4.10)

A. The mean solar day. **B.** The prime meridian.
C. 15° of longitude.
D. Two successive crossings of a celestial meridian by the sun.
E. The equator and tropics of Cancer and Capricorn.

Items 483 - 485. Select from the key the most appropriate response.

A. Statement *true;* reason has a direct bearing on the statement and is *true.*
B. Statement *true;* reason *false.*
C. Statement *false;* reason *true* but with no logical bearing on the statement.
D. Statement *false;* reason *false.*

483. *Statement:* If sidereal time were used to regulate daily affairs, it would not be necessary to adopt a regulatory understanding such as the International Date Line for the adjustment of the time.
(4.20)
Reason: All sidereal days are the same length while true (apparent) solar days vary in length throughout the year.

484. *Statement:* If a pilot were able to fly eastward around the earth at a speed of the rotation of the earth and he started the flight at noon, he would observe noon halfway around the earth and arrive at his starting point at noon, thus living two 12-hour days while those on the ground lived one 24-hour day.
(4.20)
Reason: The earth turns from west to east on its axis once in 24 hours.

485. *Statement:* Just west of the International Date Line the time is almost 12 hours less than Greenwich (G.C.T. minus 12 hrs.) and just east of the line almost 12 hours greater than Greenwich.
(4.20)
Reason: On traveling east from Greenwich, the time becomes progressively less than that of Greenwich, and to the west progressively greater.

486. When the moon passes between the earth and a star, the star disappears instantly. This fact supports the hypothesis that the moon
(4.20)

A. rotates on its axis. **B.** revolves about the earth.
C. has a low velocity of escape.
D. is moving in its orbit at a more or less uniform rate.
E. has no atmosphere.

487. The Laplacian hypothesis concerning the origin of the solar system assumes that the sun broke up and gave birth to the planets through excess rotation. Which of the following statements supports the present view that this hypothesis is untenable?
(4.20)

A. The solar material left behind by the shrinking sun could not condense because at given times there would be too few particles for condensation.
B. The hypothesis indicates that the oceans should contain more dissolved salts than they do.
C. In a dense interstellar cloud, the formation of ions in sufficient numbers to cause condensation is prevented by the lack of free movement of the atoms.
D. A nebula could not be set into rotation by the collision of the heavier particles alone.
E. All of the above.

488. The catastrophic hypothesis of Chamberlain and Moulton, concerning the origin of the solar system, assumes a collision or near collision of the sun with another astronomical body. This hypothesis is no longer acceptable because
(4.20)

A. the primeval sun could not have had sufficient rotation to have caused the postulated break-up.
B. geologists cannot find the original crust.
C. geologists have found evidence of periods of glaciation early in earth history.
D. it accounts for only one-tenth of the angular momentum of the present system.
E. of none of the above.

489. If the length of the sidereal day is assumed constant, the solar day varies. If the length of the solar day is assumed constant, the sidereal day varies. Why was not the second alternative chosen?
(4.20)

A. Phenomena such as the period of swing of a pendulum would be found to occur at varying rates during the year without any apparent cause.
B. The length of a sidereal day can be determined more accurately than the length of a solar day.
C. Observations show that the solar day does vary with respect to the sidereal day.
D. The choice is purely arbitrary and could have been made either way with identical results.
E. Ptolemy chose the sidereal day as the constant, and it is easier to follow this convention than to change it.

490. Venus shows phases like the moon. Which of the fol-
(4.20) lowing gives the best explanation of this phenomenon?

- **A.** Venus moves around the sun in an orbit within the orbit of the earth.
- **B.** Venus is smaller than the earth.
- **C.** Venus moves faster than the earth.
- **D.** Venus revolves about the earth.
- **E.** Venus is a satellite of another planet.

491. Why does a lunar eclipse last longer than a solar eclipse?
(4.20)

- **A.** During a lunar eclipse the moon is full.
- **B.** The diameter of the earth is greater than the diameter of the moon.
- **C.** During a lunar eclipse there is both an umbra and a penumbra.
- **D.** Lunar eclipses occur less often and, hence, last longer.
- **E.** The moon travels more rapidly in its orbit when closest to the sun.

492. The Lyttleton-Hoyle hypothesis, concerning the origin
(4.20) of the solar system, accounts for the fact that the planets are composed mostly of heavy elements while the sun is composed mostly of hydrogen and helium. Which statement gives their explanation of this fact?

- **A.** During its passage through an interstellar cloud, the sun attracted heavy particles toward it, these particles condensing into the planets.
- **B.** The sun captured some of the material formed when its companion star collided with a third star.
- **C.** The sun formed first from an interstellar cloud leaving the heavier elements to form the planets.
- **D.** The sun captured the heavy elements formed when a supernova exploded.
- **E.** None of the above.

Items 493 - 500.

In seeking the solution of the first problem in this course we developed a hypothesis of celestial motions which placed the earth at the center. This could be called the "Colgate" geocentric hypothesis. We later developed the heliocentric hypothesis commonly held today. Below are a number of verified observations which might be used to support either or both of these hypotheses. Indicate for each observation, by blackening the appropriate space on the answer sheet, which phrase of the key best describes the support provided. (Consider an observation to "support" a hypothesis if it could have been predicted from the hypothesis.)

KEY

- **A.** The observation supports only the Colgate geocentric hypothesis.
- **B.** The observation supports only the heliocentric hypothesis.
- **C.** The observation supports both hypotheses.
- **D.** The observation supports neither hypothesis.

493. Galileo discovered that Venus goes through phases like
(4.20) the moon and has its largest diameter in the crescent phase.

494. The moon drifts eastward in front of the stars returning
(4.20) to the same position in about 27⅓ days.

495. Some of the brighter stars make minute yearly oscilla-
(4.20) tions in position compared to the fainter stars.

496. Tycho Brahe discovered a bright star which flared up
(4.20) in the constellation of Cassiopeia.

497. The stars rise four minutes earlier each night.
(4.20)

498. All the planets are seen to make retrograde loops at
(4.20) regular intervals.

499. The plane of oscillation of a Foucault pendulum seems
(4.20) to turn at a regular rate.

500. Observation of the moon and sun shows the sun to have
(4.20) a diameter many times that of the earth, while spectroscopic studies of the sun show it to be a gaseous mass of high density and temperature in its interior.

501. Which of the following is the most correct comparison
(4.20) of the positions of the geocentric (Ptolemaic) and heliocentric (Copernican) astronomies, with regard to the question, "Does retrograde motion represent a real change in the direction of motion of a planet?"

- **A.** According to the *Copernican* theory, retrograde motion *does* represent a real change of direction; according to the *Ptolemaic* theory, it is *merely an appearance* produced by epicycles.
- **B.** According to the *Ptolemaic* theory, retrograde motion *does* represent a real change in direction; according to the *Copernican* theory, it is *merely an appearance* produced by the earth's motion.
- **C.** According to *both* theories, retrograde motion represents a *real change* of direction, produced by epicycles according to the *Ptolemaic* theory, by orbital motion around the sun according to the *Copernican* theory.
- **D.** According to *both* theories, retrograde motion represents a *real change* of direction, produced by epicycles.
- **E.** Retrograde motion does not exist, either as a real or an apparent motion, according to the *Copernican* theory; it is a kind of motion postulated by the *Ptolemaic* theory, to account for the apparent irregularity of planetary motions.

502. Which of the following best expresses the relation be-
(4.20) tween Kepler's laws and Newton's propositions concerning the forces which act in the solar system?

- **A.** Newton's propositions are made to appear probable by certain mathematical consequences of Kepler's laws, and when Newton's propositions have once been established they lead to corrections of Kepler's laws.
- **B.** Newton's propositions are made to appear probable by certain mathematical consequences of Kepler's laws, and when Newton's propositions have once been established Kepler's laws can be demonstrated.
- **C.** Newton's propositions are demonstrated as mathematical consequences of Kepler's laws, and when Newton's propositions have once been established they lead to corrections of Kepler's laws.
- **D.** Newton's propositions are demonstrated as mathematical consequences of Kepler's laws, while conversely, if Newton's propositions are assumed, Kepler's laws can be demonstrated.
- **E.** Kepler's laws provide the starting point for a demonstration which makes Newton's propositions appear probable; but the best evidence for Newton's propositions comes from the motion of the moon, and is independent of Kepler's laws; in fact Kepler's laws are regarded as valid chiefly because they are approximate consequences of Newton's propositions, not vice-versa.

503. (5.10) Outline carefully the reasoning of *one* scientific argument which supports the heliocentric hypothesis of celestial motions in preference to the "Colgate" geocentric hypothesis. (Plan before you write. Skill of expression must be demonstrated to earn a high grade on this question.)

504. (5.20) The moon is sometimes north of the celestial equator and sometimes south of it. As an observer at Hamilton, explain how you would determine, without reference to tables or handbooks, when the moon is directly on the celestial equator.

505. (5.20) Suppose you were an explorer of the Antarctic and were endeavoring to reach the South Pole. In terms of what you could observe, how would you tell whether you had gotten there or not?

506. (6.20) The statement that all parts of the moon are essentially alike in topography can best be evaluated as

A. the statement is true. **B.** the statement is false.
C. not being based on established facts.
D. being true at certain times but false at other times.

Items 507 - 514 refer to various factors related or unrelated to explaining why *our winters are colder than our summers.* For each item select from the key the correct response.

KEY

A. A statement which has a major bearing or causal relationship.
B. A statement which is true but does not cause the effect.
C. A statement which is false.
D. A statement which has only a minor bearing or causal relationship.

507. (6.20) At aphelion we are 3,000,000 miles farther from the sun than at perihelion.

508. (6.20) The angle of elevation of the sun is less than 40° in December.

509. (6.20) The earth varies in its speed in its orbit around the sun.

510. (6.20) The edge of the zone of the sun's illumination of the earth is a great circle.

511. (6.20) The earth is inclined 23.5° with the vertical axis.

512. (6.20) The number of hours of daylight is less in winter than in summer.

513. (6.20) The radiation given off by the sun is less intense in winter than in summer.

514. (6.20) The rotation of the earth on its axis is slower in winter than in summer.

5. *Geography*

GEOGRAPHY

1. (1.10) In which one of the following regions would frequent orographic precipitation probably be typical throughout the entire year?

A. Western slopes of mountains in Costa Rica.
B. Eastern slopes of mountains in southern Chile.
C. Western slopes of mountains along the coast of southern Norway.
D. Eastern slopes of mountains in Idaho.
E. Northern slopes of mountains in Java.

2. (1.10) In which one of the following regions might a person be who sees the sun directly overhead on September 21?

A. Siam. B. Iran. C. Ethiopia. D. Panama.
E. Borneo.

3. (1.10) In which one of the following regions might a person be who sees the sun directly overhead on June 21?

A. Burma. B. Southwest Africa.
C. Belgian Congo. D. Peru. E. Japan.

4. (1.10) In which one of the following regions might a person be who sees the sun directly overhead on December 21?

A. Mozambique. B. Kenya. C. Ethiopia.
D. Nigeria. E. Sudan.

5. (1.10) On March 21 near midnight in which one of the following regions might the constellation Virgo be observed directly overhead?

A. Korea. B. Uruguay. C. Morocco.
D. Sumatra. E. Bechuanaland.

6. (1.10) In which one of the following places on September 21 are the sun's rays at local noon most nearly vertical?

A. Montevideo, Uruguay. B. Calcutta, India.
C. Jerusalem, Palestine. D. Bandung, Indonesia.
E. Wellington, New Zealand.

7. (1.10) It is necessary to cross the equator in traveling from

A. Jacksonville, Florida, to Haifa, Palestine.
B. Tamatave, Madegascar, to Aden, Arabia.
C. Buenos Aires, Argentina, to Durban, South Africa.
D. Manila, Philippine Islands, to Colón, Panama.
E. Dublin, Ireland, to Georgetown, British Guiana.

8. (1.10) On June 21, in which one of the following regions would the noon sun have the greatest altitude?

A. India. B. Belgium. C. Finland.
D. South Island, New Zealand. E. Angola.

9. (1.10) It is necessary to cross the Greenwich Meridian in traveling by the shortest route from

A. Rome, Italy, to Calcutta, India.
B. Aden, Arabia, to Tamatave, Madagascar.
C. Paris, France, to Helsinki, Finland.
D. Belfast, Ireland, to Haifa, Israel.
E. Cairo, Egypt, to Calcutta, India.

10. (1.10) In which one of the following cases will solar radiation traverse the longest path through the atmosphere before striking the earth's surface at the place and time indicated?

A. Hong Kong, China, noon on June 21.
B. Quito, Eucador, noon on September 21.
C. Madrid, Spain, noon on March 21.
D. Tamatave, Madagascar, on December 21.
E. Singapore, Malay Peninsula, noon on September 21.

11. (1.10) Assuming that the atmosphere absorbs uniformly throughout, in which one of the following cases would the amount of solar radiation received per hour per square foot of earth surface be greatest?

A. Algiers, Algeria, noon on December 21.
B. Harbin, Manchuria, noon on March 21.
C. Dublin, Ireland, noon on September 21.
D. Shanghai, China, noon on December 21.
E. Calcutta, India, noon on June 21.

12. (1.10) In which one of the following cases (at the place and time mentioned) are convective thunderstorms most frequent?

A. Central Poland, from October to March.
B. Union of South Africa, April to September.
C. Northern Mongolia, from October to March.
D. Central U.S.A., from April to September.
E. Southern Argentina, from April to September.

13. (1.10) In which one of the following cases (at the place and time mentioned) are hurricanes most frequent?

A. Coral Sea, in late August, September, and early October.
B. Caribbean Sea, in late January, February, and early March.
C. South China Sea, in late August, September and early October.
D. Baltic Sea, in late February, March and early April.
E. Bering Sea, in late August, September and early October.

14. (1.10) In which one of the following regions is the weather in December and January controlled primarily by polar-front cyclones?

A. coastal Uruguay. B. coastal Kenya.
C. coastal Denmark. D. Northern Rhodesia.
E. coastal Burma.

15. (1.10) Which one of the following would probably be under horse-latitude control throughout the entire year?

A. Brittany peninsula of France.
B. Malay peninsula. C. coastal Southwest Africa.
D. Korean peninsula. E. Tasmania.

16. (1.10) Which one of the following regions would probably be under the control of the westerlies throughout the entire year?

A. Madagascar. B. Bermuda. C. West Indies.
D. East Indies. E. South Island, New Zealand.

17. (1.10) Which one of the following regions would probably receive onshore winds, converging toward a continental low, during June, and offshore winds, diverging from a continental high, during December?

A. Coastal China. B. Union of South Africa.
C. British Guiana. D. North-coastal Australia.
E. Northern Chile.

18. (1.10) In which one of the following regions would frequent polar-front cyclones occur typically during December and January?

A. Northern California. **B.** Northern Mexico.
C. Central Australia. **D.** North-coastal Alaska.
E. Nigeria.

19. (1.10) The following three statements are typical of a certain place X.

1. The prevailing winds of the place X are derived from one of the great high pressure cells which is located over the ocean due east of the place X.
2. On June 21 about 11 hours of daylight prevail in the place X.
3. Relatively warm ocean currents flow southward along the coast of the place X.

In which one of the following regions might the place X be located typically?

A. Coastal southeastern Brazil.
B. French Indo-China. **C.** Coastal Southwest Africa.
D. Coastal northern Chile. **E.** Coastal Palestine.

20. (1.10) Which one of the following regions would probably experience considerable orographic precipitation derived from southeasterly winds throughout the year?

A. British Guiana. **B.** East-coastal Honduras.
C. Central east coast of Brazil.
D. New Brunswick. **E.** Japan.

21. (1.10) Which one of the following regions lies in the rain shadow of a highland, and hence receives no orographic precipitation from prevailing winds throughout the entire year?

A. Western Washington. **B.** Western Costa Rica.
C. Southern coastal Chile.
D. Coastal British Columbia. **E.** Eastern Japan.

22. (1.10) Which one of the following regions is characterized by a climate which is conducive to formation of lateritic soils?

A. Southern Algeria. **B.** Poland. **C.** California.
D. Borneo. **E.** Northern Alaska.

23. (1.10) Which one of the following regions is characterized by a climate which is conducive to formation of Podzolic soils?

A. Honduras. **B.** Amazon valley. **C.** Finland.
D. Coastal Tripoli. **E.** Southwest Africa.

24. (1.10) Which one of the following regions has relatively warm ocean currents flowing along the coast?

A. Morocco. **B.** California.
C. Coast of eastern Australia. **D.** Southwest Africa.
E. Northern Chile.

25. (1.10) In which of the following regions do onshore northerly winds prevail during January and offshore southerly winds prevail during July?

A. West coast of peninsular India.
B. East-coastal Nicaragua.
C. Coastal southern California.
D. Coastal Southwest Africa.
E. North coast of Australia.

26. (1.10) In which one of the following regions are the prevailing winds westerly or northwesterly throughout the entire year?

A. New Zealand. **B.** Coastal China.
C. West coast of peninsular India.
D. Coastal Venezuela. **E.** East-coastal Madagascar.

27. (1.10) In general, the ocean currents along the coast of Georgia are

A. southeastward-flowing. **B.** southwestward-flowing.
C. southward-flowing. **D.** northward-flowing.
E. westward-flowing.

28. (1.10) The Dzungarian Basin is located between

A. the Tien Shan and the Altai Mountains.
B. the Transylvania Alps and the Balkans.
C. the Pyrenees and the Spanish Meseta.
D. the Black Forest and the Vosges Mountains.
E. the Sulaiman Range and the Hindu Kush.

29. (1.10) In which one of the following regions would frequent convectional precipitations probably be typical throughout the entire year?

A. Florida. **B.** South Island, New Zealand.
C. Sumatra. **D.** West-coastal peninsular India.
E. Korea.

30. (2.10) Which two of the following places are nearest to each other?

Place 1 at latitude 20°N, longitude 50°E.
Place 2 at latitude 30°N, longitude 50°E.
Place 3 at latitude 30°N, longitude 60°E.
Place 4 at latitude 20°N, longitude 60°E.

The correct answer is

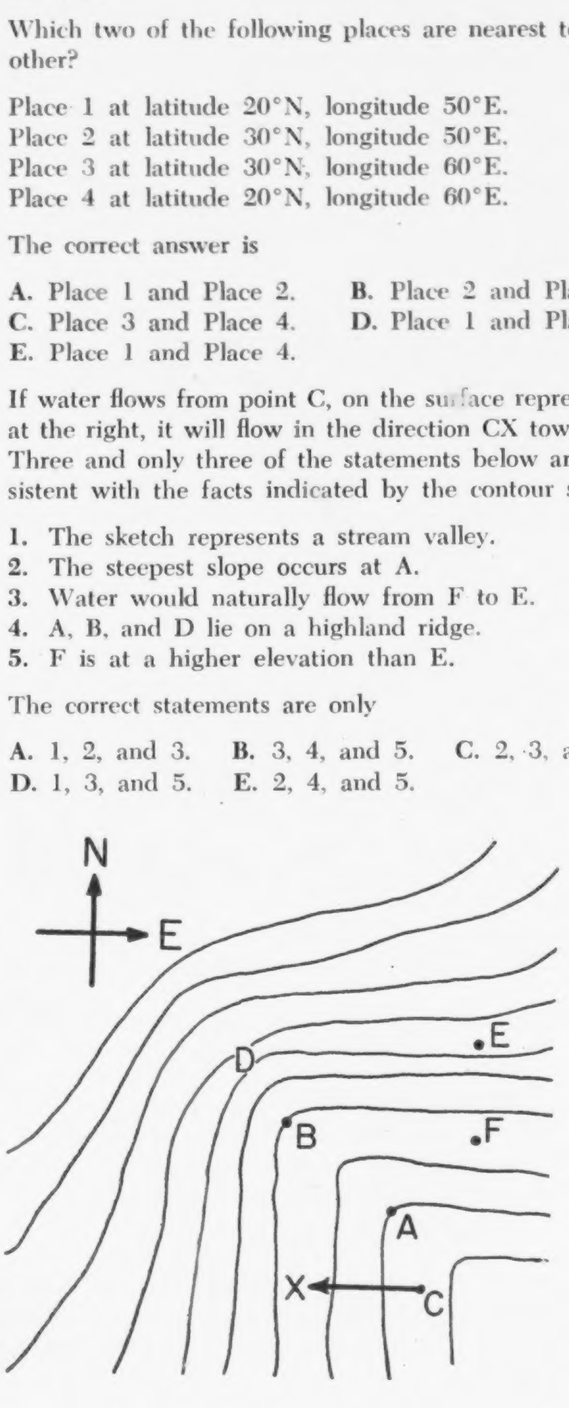
A. Place 1 and Place 2. **B.** Place 2 and Place 3.
C. Place 3 and Place 4. **D.** Place 1 and Place 3.
E. Place 1 and Place 4.

31. (2.10) If water flows from point C, on the surface represented at the right, it will flow in the direction CX toward X. Three and only three of the statements below are consistent with the facts indicated by the contour sketch.

1. The sketch represents a stream valley.
2. The steepest slope occurs at A.
3. Water would naturally flow from F to E.
4. A, B, and D lie on a highland ridge.
5. F is at a higher elevation than E.

The correct statements are only

A. 1, 2, and 3. **B.** 3, 4, and 5. **C.** 2, 3, and 4.
D. 1, 3, and 5. **E.** 2, 4, and 5.



32. (3.00) The climate pattern at the right is typical of a certain place X. In which one of the following regions might the place X be located characteristically?

	Temp.	Prec.
January	22	.04
February	24	0.5
March	32	1.0
April	45	1.9
May	54	3.5
June	64	3.4
July	71	2.5
August	70	1.7
September	60	1.3
October	48	1.0
November	36	0.5
December	27	0.4

A. Northern Germany.
B. Portugal.
C. Western South Dakota.
D. Central Alabama.
E. Arabia.

33. (3.00) The climatic pattern at the right is typical of a certain place X. In which one of the following regions might the place X be located characteristically?

	Temp.	Prec.
January	38	2.2
February	38	2.1
March	40	2.4
April	44	1.9
May	48	2.3
June	54	1.7
July	57	2.8
August	56	2.7
September	53	2.2
October	47	3.0
November	42	3.0
December	39	3.2

A. Central Turkey.
B. Coastal Peru.
C. Coastal South Carolina.
D. West-coastal Costa Rica.
E. Scotland.

34. (3.00) The climate pattern at the right is typical of a certain place X. In which of the following regions might the place X be located characteristically?

	Temp.	Prec.
January	78	13.0
February	78	13.6
March	79	7.8
April	79	4.8
May	80	3.7
June	79	3.6
July	78	2.6
August	79	1.3
September	80	2.6
October	80	4.1
November	79	5.0
December	78	8.7

A. Coastal Georgia.
B. Bandung, Indonesia.
C. Coastal Texas.
D. Formosa.
E. West-coastal Madagascar.

35. (3.00) The climatic pattern at the right is typical of a certain place X. In which one of the following regions might the place X be located characteristically?

	Temp.	Prec.
January	23	0.1
February	28	0.2
March	39	0.2
April	55	0.6
May	68	1.4
June	76	3.0
July	78	9.4
August	76	6.3
September	67	2.6
October	55	0.6
November	38	0.3
December	26	0.1

A. Coastal New York.
B. Eastern Montana.
C. Northern Rhodesia.
D. Northeastern interior China.
E. Dutch Guiana.

36. (3.00) The climatic pattern at the right is typical of a certain place X. In which one of the following regions might the place X be located characteristically?

	Temp.	Prec.
January	75	0.1
February	75	0.0
March	78	0.1
April	82	0.0
May	85	0.7
June	82	20.6
July	80	27.3
August	79	16.0
September	79	11.3
October	81	2.4
November	79	0.4
December	76	0.0

A. West-coastal peninsular India.
B. Florida.
C. Korea.
D. Southern Italy.
E. Northern coastal Australia.

37. (3.00) The climatic pattern at the right is typical of a certain place X. In which one of the following regions might the place X be located characteristically?

	Temp.	Prec.
January	60	2.9
February	59	3.2
March	57	6.4
April	54	9.3
May	51	15.3
June	49	17.5
July	46	15.4
August	46	13.5
September	49	7.3
October	51	5.0
November	53	4.4
December	57	4.8

A. Southern interior Argentina.
B. Coastal Oregon.
C. Coastal southern Chile.
D. East-coastal Australia.
E. Philippine Islands.

38. (3.00) The climatic pattern at the right is typical of a certain place X. In which one of the following regions might the place X be located characteristically?

	Temp.	Prec.
January	55	5.1
February	56	4.2
March	57	4.8
April	61	2.7
May	65	1.7
June	70	0.5
July	73	0.0
August	75	0.1
September	72	1.4
October	67	3.3
November	60	6.4
December	56	5.5

A. Coastal Nigeria.
B. Gibraltar.
C. Northeast-coastal Argentina.
D. Central Florida.
E. Oklahoma.

39. (3.00) The climatic pattern at the right is typical of a certain place X. In which one of the following regions might the place X be located characteristically?

	Temp.	Prec.
January	28	3.6
February	29	3.4
March	36	3.6
April	46	3.3
May	57	3.2
June	66	2.9
July	72	3.5
August	70	3.6
September	63	3.1
October	54	3.2
November	42	3.3
December	32	3.4

A. West-coastal Nicaragua.
B. Southeastern Australia.
C. Coastal Georgia.
D. Massachusetts.
E. Coastal Washington.

40. (3.00) The climatic pattern at the right is typical of a certain place X. In which one of the following regions might the place X be located characteristically?

- **A.** Coastal China.
- **B.** Northern Alberta, Canada.
- **C.** Coastal Norway.
- **D.** North-coastal Alaska.
- **E.** Southern Argentina.

	Temp.	Prec.
January	—14	0.6
February	—6	0.3
March	8	0.5
April	30	0.7
May	47	1.0
June	55	1.9
July	60	2.1
August	57	2.0
September	46	1.4
October	32	0.7
November	10	0.5
December	—4	0.4

41. (3.00) The climatic pattern at the right is typical of a certain place X. In which one of the following regions might the place X be located characteristically?

- **A.** Middle coastal California.
- **B.** Coastal Oregon.
- **C.** Central Kansas.
- **D.** Central Ohio.
- **E.** Nevada.

	Temp.	Prec.
January	30	0.5
February	34	0.4
March	40	0.5
April	47	0.5
May	55	0.4
June	66	0.2
July	74	0.4
August	71	0.6
September	63	0.4
October	52	0.4
November	41	0.3
December	31	0.4

42. (3.00) The climatic pattern at the right is typical of a certain place X. In which one of the following regions might the place X be located characteristically?

- **A.** Southwest Africa.
- **B.** Southern interior Argentina.
- **C.** Coastal Georgia.
- **D.** Middle west-coastal Australia.
- **E.** Middle east-coastal Australia.

	Temp.	Prec.
January	77	6.4
February	76	6.3
March	74	5.8
April	70	3.6
May	64	2.8
June	60	2.6
July	58	2.3
August	61	2.1
September	65	2.1
October	70	2.6
November	73	3.6
December	77	4.9

43. (3.00) The climatic pattern at the right is typical of a certain place X. In which one of the following regions might the place X be located characteristically?

- **A.** Coastal Southwest Africa.
- **B.** Central Australia.
- **C.** West-coastal Madagascar.
- **D.** Peninsula of Lower California.
- **E.** Southern Chile.

	Temp.	Prec.
January	63	0.0
February	63	0.1
March	63	0.2
April	60	0.0
May	61	0.0
June	59	0.0
July	57	0.0
August	55	0.0
September	56	0.0
October	58	0.1
November	59	0.0
December	62	0.2

44. (3.00) The climatic pattern at the right is typical of a certain place X. In which one of the following regions might the place X be located characteristically?

- **A.** Venezuela.
- **B.** Southwest Africa.
- **C.** Southwest-coastal Australia.
- **D.** Central Brazil.
- **E.** West-coastal peninsular India.

	Temp.	Prec.
January	81	9.6
February	81	8.9
March	81	8.1
April	80	4.1
May	78	2.0
June	75	0.2
July	77	0.2
August	78	1.1
September	81	2.0
October	83	4.4
November	82	6.0
December	81	7.9

45. (3.00) The climatic pattern at the right is typical of a certain place X. In which one of the following regions might the place X be located characteristically?

- **A.** Northern Japan.
- **B.** Eastern Colorado.
- **C.** Coastal China.
- **D.** British Guiana.
- **E.** Southern Sudan.

	Temp.	Prec.
January	53	3.1
February	51	2.5
March	62	4.8
April	67	5.3
May	73	4.6
June	78	6.0
July	86	4.3
August	86	8.7
September	81	3.0
October	72	1.3
November	66	0.8
December	57	1.3

46. (3.00) The climatic pattern at the right is typical of a certain place X. In which one of the following regions might the place X be located characteristically?

- **A.** North Dakota.
- **B.** Coastal France.
- **C.** Southern Chile.
- **D.** Southern Baffin Island.
- **E.** Scotland.

	Temp.	Prec.
January	—14	1.1
February	—12	1.3
March	—2	0.8
April	12	1.5
May	29	1.5
June	39	1.1
July	46	2.6
August	44	2.0
September	36	1.2
October	26	1.5
November	12	2.2
December	—4	1.5

47. (3.00) The climatic pattern at the right is typical of a certain place X. In which one of the following regions might the place X be located characteristically?

- **A.** Middle coastal California.
- **B.** Middle coastal Chile.
- **C.** Middle east-coastal Australia.
- **D.** East-coastal Madagascar.
- **E.** South-central Argentina.

	Temp.	Prec.
January	67	0.0
February	66	0.0
March	65	0.6
April	61	0.2
May	59	3.5
June	56	5.8
July	55	4.8
August	56	3.2
September	58	0.8
October	59	0.4
November	62	0.1
December	64	0.3

48. The climatic pattern at the right is typical of a certain place X. In which one of the following regions might the place X be located characteristically?
(3.00)

A. Iranian Plateau, south of the Caspian.
B. Central Australia.
C. Korea.
D. Eastern Texas.
E. Iowa.

	Temp.	Prec.
January	34	1.2
February	42	0.9
March	48	2.4
April	61	0.9
May	71	0.4
June	80	0.0
July	85	0.4
August	83	0.0
September	77	0.1
October	61	0.1
November	51	1.2
December	42	1.3

49. The climatic pattern at the right is typical of a certain place X. In which one of the following regions might the place X be located characteristically?
(3.00)

A. Northern coastal Australia.
B. Morocco.
C. Peninsula of Lower California.
D. Southern coastal Indo-China.
E. Bechuanaland.

	Temp.	Prec.
January	79	0.9
February	81	0.1
March	84	0.3
April	86	1.7
May	84	8.3
June	82	12.6
July	82	11.1
August	82	11.0
September	82	13.3
October	81	11.1
November	80	3.7
December	79	3.1

Items 50 - 54. Below are given climatic patterns for five different places.

	1		2		3	
	Temp.	Prec.	Temp.	Prec.	Temp.	Prec.
January	75	4.1	9	2.5	69	0.0
February	75	3.0	10	2.4	67	0.1
March	75	3.0	22	2.4	62	0.2
April	77	4.1	34	1.9	57	0.6
May	79	5.2	44	3.0	51	2.4
June	80	5.4	53	3.6	46	3.3
July	80	5.8	58	2.9	46	2.8
August	80	5.9	56	3.2	49	2.1
September	80	6.0	49	3.1	52	1.3
October	80	5.7	41	3.3	57	0.5
November	78	7.0	30	2.9	62	0.2
December	76	5.4	17	2.8	67	0.2

	4		5	
	Temp.	Prec.	Temp.	Prec.
January	80	2.1	50	1.0
February	81	2.3	54	0.7
March	82	3.7	60	0.6
April	80	6.1	67	0.4
May	79	1.9	75	0.1
June	75	0.0	84	0.1
July	73	0.0	90	1.3
August	73	0.1	88	1.0
September	76	0.1	82	0.7
October	79	1.6	70	0.5
November	80	5.9	59	0.8
December	80	4.7	52	0.7

50. In which one of the above places would the original vegetation cover typically be dense evergreen broadleaf forest?
(3.00)

A. 1. **B.** 2. **C.** 3. **D.** 4. **E.** 5.

51. In which place would the original vegetation cover typically be desert shrub or sparse bunch grass?
(3.00)

A. 1. **B.** 2. **C.** 3. **D.** 4. **E.** 5.

52. In which place would the original vegetation cover typically be coniferous forest?
(3.00)

A. 1. **B.** 2. **C.** 3. **D.** 4. **E.** 5.

53. In which place would the original vegetation cover typically be drought-resistant shrub woodland?
(3.00)

A. 1. **B.** 2. **C.** 3. **D.** 4. **E.** 5.

54. In which place would the original vegetation cover typically be tall tuft grass or tropical scrub and thorn woodland?
(3.00)

A. 1. **B.** 2. **C.** 3. **D.** 4. **E.** 5.

55. Which one of the following rocks is most likely to be formed from sedimentation beds?
(1.10)

A. obsidian. **B.** granite. **C.** conglomerate.
D. basalt. **E.** granite-gneiss.

56. Which one of the following rocks is a metamorphic rock?
(1.10)

A. conglomerate. **B.** sandstone. **C.** basalt.
D. marble. **E.** limestone.

57. Which one of the following rocks is formed by slow cooling of magna?
(1.10)

A. obsidian. **B.** conglomerate. **C.** mica.
D. shale. **E.** granite.

58. Which one of the following rocks is formed by the cooling of magma in two stages, one slow and one rapid?
(1.10)

A. conglomerate. **B.** granite-gneiss. **C.** mica slate.
D. basalt-porphyry. **E.** marble.

59. Three, and only three, of the following land forms belong in a certain common category.
(1.23)

1. graben. **2.** batholith. **3.** stock.
4. horst. **5.** fault.

The certain common category is land forms which are due principally to

A. crustal fracture. **B.** extrusion of lava.
C. crustal folding. **D.** intrusion of magma.
E. crustal warping.

60. The following tabulation is taken from one of the common "patent medicine" almanacs.
(3.00)

Date	Day of Week	Moon's Constellation	
7	Sunday	Sagittarius	moon rises 10:38 p.m.
8	Monday	Sagittarius	moon rises 11:20 p.m.
9	Tuesday	Capricornus	moon rises 11:58 p.m.
10	Wednesday	Capricornus	
11	Thursday	Capricornus	moon rises 12:32 a.m.
12	Friday	Aquarius	moon rises 1:04 a.m.
13	Saturday	Aquarius	moon rises 1:35 a.m.

To which one of the following months might the above data be applicable?

A. May. **B.** March. **C.** January.
D. November. **E.** August.

61. (3.00) On a date when mean and apparent solar time agreed, a ship's chronometer registered 4:20 a.m. (Greenwich mean solar time) just as the sun crossed the meridian due south of the ship's position. In which one of the following regions might the ship have been at the time of the above observation?

A. Mediterranean Sea. **B.** North Sea.
C. Caribbean Sea. **D.** Black Sea.
E. South China Sea.

62. (3.00) If on a date when the sun's declination is 20°S the planet Jupiter is on the meridian at some place at midnight (local apparent solar time), then at that time Jupiter might be observed on the meridian and south of the zenith at a place in

A. Kenya. **B.** Java. **C.** Peru. **D.** Spain.
E. Tanganyika.

63. (3.00) A ship captain, taking observations from the bridge of his ship, observed the sun at an altitude of 40° when it crossed the meridian to the south of him. The Nautical Almanac gives the sun's declination at that instant as 15°S. In which one of the following regions might the ship have been at the time of the above observation?

A. North Sea. **B.** Mediterranean Sea.
C. Indian Ocean. **D.** Baffin Bay. **E.** Arctic Ocean.

64. (3.00) On April 23, 1948, at 1:28 p.m. (Greenwich mean solar time) the moon was in full phase. At that time in which one of the following regions might an observer have seen the moon on the meridian?

A. North Sea. **B.** Baltic Sea. **D.** Coral Sea.
D. Red Sea. **E.** Caribbean Sea.

65. (3.00) If on some date at 8:00 p.m. (Greenwich mean solar time) the planet Jupiter crosses the meridian at a place X at midnight (local mean solar time), then the place X might be located in

A. the United States. **B.** Iran. **C.** Italy.
D. Ireland. **E.** Philippine Islands.

66. (3.00) On a certain date the star Regulus crossed the Greenwich meridian at 11:00 p.m. (Greenwich mean solar time). On that same date the star Regulus crossed the meridian at a place X at 10:40 p.m. (Greenwich mean solar time). In which one of the following regions might the place X be located?

A. France. **B.** New Zealand. **C.** Uruguay.
D. Egypt. **E.** United States.

67. (3.00) On October 21 about 6 hours after local noon, which one of the following constellations might be on or near the meridian of an observer?

A. Virgo. **B.** Gemini. **C.** Capricornus.
D. Pisces. **E.** Taurus.

68. (3.00) The zenith distance of the sun as observed from Tokyo, Japan, on a certain date is 50° when the sun is due south of the observer. What would be the zenith distance of the sun as observed simultaneously from a place which is 600 nautical miles due north of Tokyo?

A. 40°. **B.** 60°. **C.** 56°. **D.** 44°. **E.** 10°.

69. (3.00) The altitude of the sun as observed from Perth, Australia (lat. 32°S, long. 117°E), on a certain date was 48° when the sun was due north of the observer. What is the latitude of the place where the sun was directly overhead at the time of the observation?

A. 10°S. **B.** 10°N. **C.** 16°S. **D.** 16°N.
E. 0°.

70 - 71. On a date when mean and apparent solar time agreed, the sun crossed the meridian at a certain place X when the time at Greenwich, England, was 5:40 a.m. (Greenwich mean solar time).

70. (3.00) What is the longitude of the place X?

A. 95°E. **B.** 54°E. **C.** 54°W. **D.** 85°W.
E. 126°E.

71. (3.00) In which one of the following regions might the place X be located?

A. Plateau of Iran. **B.** Burma. **C.** Korea.
D. Campos of Brazil. **E.** Hudson Bay.

72. (3.00) On a date when the moon is in new phase, about what part of the day does the moon set at New Orleans, Louisiana (lat. 30°N, long. 90°W)?

A. midnight. **B.** sunrise. **C.** noon. **D.** sunset.
E. between sunrise and noon.

73. (3.00) If the moon is in new phase on February 10, on or near what date in March of the same year will the moon be in last-quarter phase?

A. March 2. **B.** March 10. **C.** March 18.
D. March 24. **E.** March 27.

74 - 75. In a certain year, the moon was in full phase at the time of the summer solstice.

74. (3.00) What was the approximate declination of the moon at the above time?

A. between 5°S and 5°N.
B. between 7°S and 17°S.
C. between 7°N and 17°N.
D. between 18½°S and 28½°S.
E. between 18½°N and 28½°N.

75. (3.00) In which one of the following regions might the moon have been observed directly overhead at the above time?

A. Chile. **B.** Sinkiang. **C.** Hungary
D. Gold Coast. **E.** South Island, New Zealand.

76. (3.00) If in some year the moon was in first-quarter phase on December 21, approximately what was the declination of the moon?

A. between 18½°S and 28½°S.
B. between 5°N and 5°S.
C. between 7½°N and 12½°N.
D. between 7½°S and 12½°S.
E. between 18½°N and 28½°N.

77. (3.00) If on a date when the sun's declination is 20°S the planet Jupiter is on the meridian at a place X at midnight (local apparent solar time), then the declination of Jupiter at that time is between

A. 12°N and 28°N. B. 12°S and 28°S.
C. 5°N and 10°N. D. 5°S and 10°S.
E. 8°N and 8°S.

78. (3.00) If on some date at 5:00 a.m. (Greenwich mean solar time) the planet Jupiter crosses the meridian at a place X at midnight (local mean solar time), then the longitude of the place X is

A. 150°W. B. 105°W. C. 105°E. D. 75°W.
E. 75°E.

79 - 80. Suppose that the moon were in first-quarter phase on March 1.

79. (3.00) In which one of the following zodiacal constellations would the moon appear?

A. Aquarius. B. Libra. C. Scorpius.
Leo. E. Taurus.

80. (3.00) In which one of the signs of the zodiac would the moon appear?

A. Gemini. B. Sagittarius. C. Virgo.
D. Capricornus. E. Aries.

81. (3.00) On a certain date a star S crossed the meridian at a place X at 11:00 p.m., local mean solar time. At about what time (local mean solar time) did the same star S cross the meridian at the same place X 15 days later?

A. 10:00 p.m. B. 1:00 a.m. C. 9:00 p.m.
D. 3:00 a.m. E. 11:00 p.m.

82. (3.00) Estimate roughly the duration of daylight in Helsinki, Finland (lat. 60°N, long. 25°E), on June 21. It is, roughly,

A. 5 hours. B. 15 hours. C. 9 hours.
D. 19 hours. E. 16 hours.

83. (3.00) Estimate roughly the local time of sunrise (local mean solar time) at Naples, Italy (lat. 40°N, long. 14°E), on December 21. It is about

A. 6:00 a.m. B. 5:30 a.m. C. 8:15 a.m.
D. 6:30 a.m. E. 7:30 a.m.

84. (3.00) Estimate roughly the local time of sunset (local mean solar time) at Santa Cruz, Argentina (lat. 50°S, long. 69°W), on June 21. It is about

A. 4:00 p.m. B. 5:00 p.m. C. 6:00 p.m.
D. 7:00 p.m. E. 8:00 p.m.

85. (3.00) On a certain day an explorer at a place X noted that his line of sight to the sun made an angle of 40° with the horizontal plane at X when the sun was due north of directly overhead. If the sun on that day was directly overhead in latitude 10°N, what was the latitude of the explorer's position?

A. 10°N. B. 20°S. C. 30°N. D. 40°S.
E. 50°N.

86. (3.00) On a date when the moon was in last-quarter phase the moon crossed the meridian at a certain place X at about 10:00 p.m. (Greenwich mean solar time). Approximately what is the longitude of the place X?

A. 60°E. B. 30°W. C. 30°E. D. 120°W.
E. 120°E.

87. (3.00) On a certain date, the moon crossed the meridian at Amarillo, Texas (lat. 35°N, long. 102°W) at about 6:48 p.m. (Greenwich mean solar time). In what phase was the moon at that time?

A. new. B. first-quarter. C. full.
D. last-quarter. E. waxing-gibbous.

88. (3.00) On a certain date the star Antares crossed the Greenwich meridian at 11:00 p.m. (Greenwich mean solar time). On that same date the star Antares crossed the meridian at a place X at 1:00 a.m. (Greenwich mean solar time). Approximately what is the longitude of the place X?

A. 15°W. B. 15°E. C. 30°W. D. 30°E.
E. 45°W.

89. (3.00) An observer noted one night that the zenith distance of the Pole Star was about 40°. About what was the latitude of the observer at the time of this observation?

A. 20°N. B. 40°N. C. 50°N. D. 60°N.
E. 90°N.

90 - 92. On September 21 at a certain moment the sun is directly overhead at a place Y which is 3105 statute miles due south of a certain place X.

90. (3.00) What is the angle between the earth's radius at X and the earth's radius at Y?

A. 31°. B. 45°. C. 0°. D. 25°. E. 55°.

91. (3.00) What is the latitude of the place X?

A. 20°N. B. 20°S. C. 45°N. D. 45°S.
E. 25°N.

92. (3.00) In which one of the following regions might the place X be located?

A. Egypt. B. France. C. Mexico.
D. Madagascar. E. Uruguay.

93 - 94. A ship captain, taking observations from the bridge of his ship, observed the sun on his meridian 35° south of his zenith. The Nautical Almanac indicated that the sun at that instant was directly overhead at a place whose latitude is 20°S.

93. (3.00) What was the latitude of the ship at the time of the above observation?

A. 55°S. B. 15°N. C. 55°N. D. 15°S.
E. 35°S.

94. (3.00) In which one of the following regions might the ship have been at the time of the above observation?

A. Black Sea. B. Bering Sea.
C. South Atlantic Ocean. D. Coral Sea.
E. South China Sea.

95 - 96. The zenith distance of the sun as observed from Belgrade, Yugoslavia (lat. 44°N, long. 20°E), on a certain date was 21° when the sun was due south of the observer.

95. (3.00) What is the latitude of the place where the sun was directly overhead at the time of the above observation?

A. 21°N. **B.** 23°N. **C.** 20°S. **D.** 23°S.
E. 21°S.

96. (3.00) In which one of the following regions was the sun directly overhead at the time of the above observation?

A. Paraguay. **B.** Formosa. **C.** Cuba.
D. Libya. **E.** New Zealand.

97. (3.00) If one starts at a place X (lat. 20°N, long. 60°W) and travels 240 nautical miles due south, then 240 nautical miles due west, then 240 nautical miles due north, and finally 240 nautical miles due east, one will arrive

A. south of X. **B.** north of X. **C.** at X.
D. east of X. **E.** west of X.

98. (3.00) What is the standard time and date in Cairo, Egypt (lat. 30°N, long 31°E), when the time and date in Greenwich, England, is 11:00 p.m., October 12 (Greenwich mean solar time)?

A. 9:00 p.m., October 12. **B.** 1:00 a.m., October 13.
C. 3:00 a.m., October 11. **D.** 9:00 a.m., October 11.
E. 1:00 p.m., October 12.

6. *Rocks, Minerals, and Structure of the Earth*

ROCKS, MINERALS, AND STRUCTURE OF THE EARTH

Items 1 - 6. Below are six statements. Indicate which category of the key best applies to each statement by circling the appropriate letter at the left.

KEY

A. Applies only to the "ocean of *air*."
W. Applies only to the "ocean of *water*."
B. Applies to both oceans.
N. Applies to neither ocean.

1. (4.20) A W B N Pressure in it increases in direct proportion to depth.

2. (1.10) A W B N Its density is the weight of a unit volume.

3. (4.20) A W B N Buoyancy of a rigid object submerged in it decreases as pressure increases.

4. (1.10) A W B N Is heated from below primarily by solar radiation.

5. (1.30) A W B N A sample of it will heat if subjected to increased pressure.

6. (1.30) A W B N Buoyancy of an object submerged in it can be traced to the greater pressure at the bottom of the object than that at the top.

7. (1.10) Which of the following pairs of elements are the most abundant in the lithosphere of the earth?

A. Nitrogen and oxygen. **B.** Oxygen and silicon.
C. Silicon and aluminum. **D.** Calcium and silicon.
E. Hydrogen and oxygen.

8. (1.10) Which one of the following metals does *not* occur as a free metal in the lithosphere?

A. Zinc. **B.** Copper. **C.** Gold. **D.** Silver.

9. (1.10) Which one of these is third in order of increasing density?

A. Hydrosphere. **B.** Centrosphere.
C. Troposphere. **D.** Lithosphere.
E. Stratosphere.

10. (1.10) Strata of limestone are intruded by a large mass of molten igneous rock. The limestone adjacent to the igneous mass is likely to be changed to

A. chert. **B.** marble. **C.** shale. **D.** slate.
E. marl.

11. (1.10) All of these may be produced by chemical weathering *except*

A. quartz. **B.** diamond. **C.** kaolin.
D. calcite. **E.** limonite.

12. (1.10) The fine-grained texture of an igneous rock is produced by

A. rapid cooling. **B.** slow cooling.
C. cooling deep down in the earth.
D. long transportation by streams.
E. not solidifying.

13. (1.10) A variety of granite is found in Michigan which has very large crystals of feldspar some an inch or more in size, imbedded in a finer groundmass. The texture of this granite would be termed

A. porphyritic. **B.** pegmatitic. **C.** syenitic.
D. felsitic. **E.** glassy.

For items 14 - 30 mark:

A. if the material named in the item is a mineral.
B. if the material named in the item is an extrusive igneous rock.
C. if the material named in the item is an intrusive igneous rock.
D. if the material named in the item is a sedimentary rock.
E. if the material named in the item is a metamorphic rock.

14. (1.10) Andesite. **15.** (1.10) Limestone.

16. (1.10) Calcite (crystalline calcium carbonate).

17. (1.10) Quartzite. **18.** (1.10) Shale. **19.** (1.10) Pumice.

20. (1.10) Obsidian. **21.** (1.10) Basalt. **22.** (1.10) Slate.

23. (1.10) Gabbro. **24.** (1.10) Mica. **25.** (1.10) Rhyolite.

26. (1.10) Diorite. **27.** (1.10) Feldspars. **28.** (1.10) Marble.

29. (1.10) Gneiss. **30.** (1.10) Schist.

31. (1.10) Of the following, the one that would be classed as a chemical sediment is

A. chert. **B.** sandstone. **C.** shale. **D.** tuff.
E. conglomerate.

32. (1.10) Which one of these is correct?

A. The density of rocks below the lithosphere varies inversely with the depth.
B. At a depth of 25 miles, rocks are in a molten condition.
C. Volcanic lava is proof that the center of the earth is molten.
D. Very deep mines are naturally cooler than outside.
E. Rocks at great depth have a higher melting temperature than they would have at the surface.

33. (1.10) The feldspar minerals are complex compounds composed of sodium, potassium, or calcium silicates in various combinations, principally with the silicate of

A. magnesium. **B.** iron. **C.** aluminum.
D. manganese. **E.** lithium.

34. Sandstone is a sedimentary rock which is usually characterized by
(1.10)

A. high porosity. **B.** low permeability.
C. composition of fine clay. **D.** columnar jointing.
E. high resistance to erosion.

35. Generally speaking, the material immediately beneath a coal seam is an underclay which is characterized as
(1.10)

A. representing an old regolith.
B. being an unconformity.
C. being largely sandstone.
D. being laid down under marine conditions.
E. being largely limestone.

36. A naturally-occurring inorganic substance having a definite chemical composition and, as a rule, a definite form and structure is properly called
(1.10)

A. an organic compound. **B.** coal.
C. a physical property. **D.** a mineral.
E. a mixture.

37. Igneous rocks are those which
(1.10)

A. have been transported by wind.
B. have solidified from molten material.
C. usually contain abundant calcite.
D. are always light in color.
E. are always dark in color.

38. Which of the following is *not* a sedimentary rock?
(1.10)

A. Limestone. **B.** Granite. **C.** Sandstone.
D. Shale. **E.** Conglomerate.

39.	A. Conglomerate	a. Ocean deposition
(1.10)	B. Granite	b. Glacial deposition
	C. Limestone	c. Cooled lava

Which one of the following choices correctly matches the above rocks and methods of formation?

A. Aa Bb Cc. **B.** Aa Bc Cb. **C.** Ab Ba Cc.
D. Ab Bc Ca. **E.** Ac Ba Cb.

40. The mineral which is very soft, and composed of thin elastic plates that separate easily is called
(1.10)

A. galena. **B.** calcite. **C.** quartz. **D.** mica.
E. feldspar.

41. a. Limestone b. Shale c. Schist
(1.10) d. Conglomerate e. Obsidian

Which one of the following choices lists all and only the sedimentary rocks given in the above list?

A. abc. **B.** ab. **C.** bde. **D.** abd. **E.** ce.

42. An igneous rock intruded so that it conforms to the layers of sedimentary rock is called a
(1.10)

A. dike. **B.** sill. **C.** batholith.
D. volcanic neck. **E.** laccolith.

Items 43 - 46 are matching questions, for example, matching land forms with the agencies causing them; rock names with type of rock; identifying minerals from descriptions, and so forth. For each item select from the key the correct pairing sequence of those on the left with those on the right.

KEY

A. X - A; Y - B; Z - C. **B.** X - A; Y - C; Z - B.
C. X - B; Y - A; Z - C. **D.** X - C; Y - A; Z - B.
E. Some other matching arrangement.

43.	X. basalt	A. metamorphic
(1.10)	Y. limestone	B. sedimentary
	Z. marble	C. igneous

44. (1.10)	X. quartz	A. soft mineral which splits in thin sheets
	Y. calcite	B. effervesces with HCl.
	Z. mica	C. hardness 7, glassy, shows no cleavage

45.	X. rock salt	A. silicate
(1.10)	Y. mica	B. halide
	Z. silica	C. oxide

46.	X. earthy	A. cleavage
(1.10)	Y. pegmatitic	B. fracture
	Z. cubic	C. texture

Items 47 - 49 involve the classification of minerals. For each item select from the key the proper response.

KEY

A. Exotic color	metallic luster	light streak
B. Inherent color	non-metallic luster	light streak
C. Exotic color	non-metallic luster	light streak
D. Inherent color	metallic luster	dark streak
E. Inherent color	metallic luster	light streak

47. Fluorite. **48.** Galena. **49.** Magnetite.
(1.10) (1.10) (1.10)

50. Which one of these statements is false?
(1.10)

A. All rocks of the earth are composed of minerals.
B. Minerals in the earth show a great range of chemical composition.
C. Minerals can be identified through a study of their physical properties.
D. All metals are obtained from mineral deposits.
E. All chemical alterations in minerals result from diastrophic forces.

51. a. The crystals of a coarse-grained igneous rock require a longer time to form than those of a fine-grained igneous rock.
(1.10)
b. Fine-grained igneous rocks are those that were formed from magma that came close to the surface of the earth.
c. Glassy and porous rocks probably issued in the form of magma at a fissure or a volcano and cooled at the surface.

Which one of the following choices lists all and only the statements above which are true?

A. a. **B.** b. **C.** ab. **D.** bc. **E.** abc.

52. A rock had the following characteristics: stratified and non-calcareous, composition largely kaolin, low permeability, easily broken into thin plates, and minute pore spaces. The rock would most likely be
(1.10)

A. limestone. **B.** coal. **C.** shale.
D. conglomerate. **E.** sandstone.

Item 53 deleted.

54. (1.10) Sedimentary deposits of clay or mud after being subjected to pressure change to layers of

A. conglomerate. **B.** sandstone. **C.** shale.
D. limestone. **E.** chert.

55. (1.10) Further pressure exerted on the rock referred to in the preceding item may ultimately change it to

A. marl. **B.** marble. **C.** quartzite. **D.** slate.
E. flint.

56. (1.10) All of the following are features of sedimentary rocks except

A. fossils. **B.** foliation. **C.** bedding.
D. mud cracks. **E.** raindrop impressions.

For items 57 - 61 select from the key the type of rock for which the item is characteristic.

KEY

A. Sedimentary rock. **B.** Igneous rock.
C. Metamorphic rock. **D.** Two of the above.
E. All three rock classes.

57. (1.10) Composed of minerals. **58.** (1.10) Foliated.

59. (1.10) Contains fossils. **60.** (1.10) Bedded. **61.** (1.10) Vesicular.

62. (1.10) All of the following contribute to the belief that the atmosphere of gas which envelops the earth is several hundred miles deep *except*

A. meteors which fall into the earth begin to burn at a distance of about 200 miles from the earth's surface.
B. The Aurora Borealis appears at altitudes as high as 500 miles above the earth's surface.
C. information concerning the atmosphere to a height of 250 miles above the earth's surface has been obtained by means of rockets.
D. reasoning from knowledge of changes in atmospheric density and pressure with height, the depth of the atmosphere has been computed to be several hundred miles.
E. All of the above contribute to this belief.

63. (1.10) Inherent color in a mineral is

A. the color produced by impurities.
B. color associated with metallic luster.
C. characteristic of the pure compound.
D. the exotic color of the specimen.
E. variation in the depth of color in the specimen.

For items 64 - 66 select from the key the type of unconsolidated sediments from which each was formed. Then mark the answer space whose number corresponds to the number of the answer selected.

KEY

A. Gravel. **B.** Quartz grains. **C.** Clay.
D. Calcareous material. **E.** None of these.

64. (1.10) Sandstone. **65.** (1.10) Limestone. **66.** (1.10) Shale.

Items 67 - 70 refer to the various properties of rocks and minerals. For each item select from the key the general term which applies.

KEY

A. Cleavage. **B.** Fracture. **C.** Structure.
D. Texture. **E.** None of these.

67. (1.10) Porphyritic. **68.** (1.10) Acidic.

69. (1.10) Cubic. **70.** (1.10) Foliated.

71. (1.10) All of the following are characteristics used in the identification of rocks except

A. texture. **B.** structure. **C.** fracture.
D. origin. **E.** mineral composition.

72. (1.10) Which one of these shows *no* fracture?

A. Quartz. **B.** Calcite. **C.** Asbestos.
D. Hornblende. **E.** Orthoclase.

73. (1.10) Which of the following is softest?

A. Corundum. **B.** Quartz. **C.** Gypsum.
D. Fluorite. **E.** Orthoclase.

74. (1.10) a. Fingernail b. Glass c. Obsidian
d. Limestone

Which of the following correctly groups the above in order of increasing hardness?

A. a, b, c, d. **B.** a, d, b, c. **C.** b, c, d, a.
D. d, a, c, b. **E.** c, a, d, b.

75. (1.10) a. Limestone b. Shale c. Schist
d. Conglomerate e. Obsidian

Which one of the following choices lists all and only the sedimentary rocks given in the above list?

A. a, b, c. **B.** a, b. **C.** b, d, e.
D. a, b, d. **E.** c, e.

76. (1.10) Igneous rocks with crystals which are easily seen

A. were formed at or near the surface of the lithosphere.
B. are generally found in a lava flow.
C. are always metamorphic.
D. cooled from molten magma at a very slow rate.
E. have structures known as foliation.

77. (1.10) Chemical alteration and recrystallization is characteristic of rocks classified as

A. igneous. **B.** metamorphic. **C.** sedimentary.
D. two of the preceding. **E.** three of the previous.

78. (1.10) Crystallization or recrystallization in metamorphic rocks producing alignment of minerals into bands is known as

A. colluvial deposition. **B.** bedding.
C. paludal deposition. **D.** foliation.
E. crenulation.

79. (1.10) Marble is recrystallized

A. shale. **B.** sandstone. **C.** granite.
D. quartzite. **E.** limestone.

80. (1.10) Galena, lead ore, is found as

A. an oxide. **B.** a carbonate. **C.** a sulfide.
D. a pure substance, or uncombined.
E. a by-product of iron ores.

81. (1.10) Which one of the following minerals is most abundant in the lithosphere?

A. Mica. **B.** Quartz. **C.** Calcite.
D. Gypsum. **E.** Galena.

82. (1.10) Which one of these metamorphic rocks is non-foliated?

A. Quartzite. **B.** Mica schist. **C.** Granite gneiss.
D. Grey slate. **E.** All of these are foliated.

83. (1.10) Foliated as used in geology refers to

A. cleavage. **B.** fracture. **C.** hardness.
D. structure. **E.** texture.

84. (1.10) Considering the way rocks are formed, which one of these would have the finest texture?

A. Gabbro. **B.** Basalt. **C.** Granite.
D. Conglomerate. **E.** Diorite.

85. (1.10) Gypsum is harder than

A. calcite. **B.** quartz. **C.** orthoclase.
D. fluorite. **E.** none of these.

86. (1.10) Sedimentary rocks are easily recognized because they are

A. found only in mountains. **B.** usually stratified.
C. often fused and show indications of having been melted.
D. found in volcanoes.
E. always composed of the mineral calcite.

87. (1.10) Slate and shale differ chiefly

A. in appearance. **B.** in general structure.
C. in geologic processes to which they have been subjected.
D. as to the geologic period of time in which they were formed.
E. as to whether formed under marine or continental conditions.

88. (1.10) The *second* most abundant element in the lithosphere is

A. hydrogen. **B.** oxygen. **C.** silicon.
D. iron. **E.** nitrogen.

89. (1.10) That characteristic that would be *least* useful in distinguishing sedimentary rocks from the other classes is

A. bedding. **B.** color. **C.** fossil content.
D. ease of breakage. **E.** porosity.

90. (1.10) Labradorite exhibits a definite change in color when viewed from different angles. This is caused by

A. twinning. **B.** fluorescence. **C.** foliation.
D. exotic coloration. **E.** phosphorescence.

91. (1.10) The sphere of the earth with the smallest average thickness in miles is the

A. hydrosphere. **B.** troposphere.
C. centrosphere. **D.** lithosphere.
E. stratosphere.

92. (1.10) It can be accurately assumed that all igneous rocks with clearly defined and easily observed crystals

A. were formed at or near the surface of the lithosphere.
B. are generally found in a lava flow.
C. are always metamorphic.
D. cooled from molten magma at a very slow rate.
E. show evidence of having undergone foliation.

93. (1.10) A mineral with a chemical formula $Al_2O_3 \cdot nH_2O$ and which has a clay-like odor is

A. bauxite. **B.** biotite. **C.** calcite. **D.** talc.
E. limonite.

94. (1.10) A mineral is a naturally occurring substance with characteristic chemical composition and generally reflecting crystalline structure by external geometrical form. As thus defined which of the following is *not* a mineral?

A. Copper. **B.** Common salt. **C.** Ice.
D. Lava. **E.** Carbon.

95. (1.10) A sulfide mineral is described as having a metallic luster, and cubic cleavage. This mineral

A. has a formula of ZnS.
B. is metallic and yellow in color.
C. is a major ore of lead.
D. has a specific gravity of .5.
E. is the second most common mineral.

96. (1.10) A distinction can most conveniently be made between calcite and quartz by observing

A. color. **B.** streak. **C.** hardness. **D.** luster.
E. structure.

97. (1.10) Heating limonite, a yellow hydrated iron oxide, yields

A. metallic iron.
B. a compound with a characteristic red color.
C. a product useful in neutralizing acid soils.
D. good brick-making material.
E. precipitation of calcareous tufa.

98. (1.10) A foliated rock indicates that at the time of its formation it was subjected to

A. recurrent freezing and thawing.
B. high temperatures. **C.** tilting.
D. isomorphism. **E.** great pressure.

99. (1.10) The one of the following which may be classed as a mineral is

A. quartz. **B.** obsidian. **C.** basalt.
D. scoria. **E.** all of the above.

100. (1.10) The cooling of extrusive magma with entrapped gases may form

A. scoria. **B.** obsidian. **C.** andesite.
D. rhyolite. **E.** granite.

101. (1.10) Gypsum is

A. a carbonate. **B.** an oxide. **C.** a silicate
D. a sulfate. **E.** a sulfide.

102. (1.10) The controlling factor which causes some metamorphic rocks to be foliated is

A. the variation of temperature during the process.
B. the completeness of melting and recrystallization.
C. the presence of shearing forces.
D. the difference in the hardness of the rock material.
E. the variation of density during the process.

103. (1.10) Sedimentary rocks are geologically important because of all of the following *except*

A. the extent of foliation shows the magnitude of the pressure under which they were formed.
B. they show from their attitude something of the extent of the movement of the earth's crust.
C. their structures furnish clues to the process involved in their origin.
D. they indicate the age of the strata from their contained fossils.
E. sedimentary processes concentrate many minerals.

104. (1.10) The dominant composition of a grey shale formation should be

A. kaolinite. **B.** hornblende. **C.** calcite.
D. quartz. **E.** feldspar.

Items 105 - 111 refer to terms used to describe the properties of rocks and minerals. For each item select from the key the property to which the term applies.

KEY

A. Cleavage. **B.** Fracture. **C.** Structure.
D. Texture. **E.** None of these.

105. (1.10) Foliated.
106. (1.10) Rhombic.
107. (1.10) Exotic.
108. (1.10) Earthy.
109. (1.10) Fibrous.
110. (1.10) Porphyritic.
111. (1.10) Acidic.

Items 112 - 115 refer to ores from which it is profitable to extract metals. For each item select from the key the form in which the ore is found.

KEY

A. Uncombined. **B.** Hydrated oxide. **C.** Oxide.
D. Carbonate. **E.** Sulfide.

112. (1.10) Galena, lead ore.
113. (1.10) Sphalerite, zinc ore.
114. (1.10) Copper ore, Michigan.
115. (1.10) Hemitite, iron ore, Minnesota.

Items 116 - 118 deleted.

119. (1.10) Which one of these rocks was formed on or near the earth's surface?

A. Obsidian. **B.** Gabbro. **C.** Diorite.
D. Granite. **E.** None of these.

120. (1.10) Which one of the following represents the type of unconsolidated sediments from which limestone was formed?

A. Clay. **B.** Gravel. **C.** Plant remains.
D. Quartz grains. **E.** None of the above.

121. (1.10) Slate can be classified as

A. igneous, intrusive. **B.** igneous, extrusive.
C. metamorphic, foliated.
D. metamorphic, non-foliated. **E.** sedimentary.

122. (1.10) The layering or stratification of sediments and sedimentary rocks sometimes shown by bands of color in very fine-grained sediments is

A. a concretion. **B.** alluvial fanning.
C. bedding. **D.** foliation. **E.** loess.

123. (1.10) The color in a mineral which does not show in the streak is

A. called inherent color.
B. an optical illusion caused by the way the light is reflected.
C. characteristic of all pure specimens.
D. called metallic luster. **E.** caused by impurities.

Item 124 deleted.

125. (1.10) Inherent color in a mineral is

A. the color produced by impurities.
B. color associated with metallic luster.
C. characteristic of the pure compound.
D. the exotic color of the specimen.
E. variation in the depth of color in the specimen.

Items 126 - 130 refer to various properties of rocks and minerals. For each item select from the key the general term which applies.

KEY

A. Cleavage. **B.** Fracture. **C.** Structure.
D. Texture. **E.** None of these.

126. (1.10) Porphyritic.
127. (1.10) Acidic.
128. (1.10) Cubic.
129. (1.10) Foliated.
130. (1.10) Earthy.

131. (1.10) "Blocky" as used in geology refers to

A. cleavage. **B.** fracture. **C.** hardness.
D. structure. **E.** texture.

132. (1.10) In Moh's hardness scale, apatite has a hardness

A. of 3 or less. **B.** from 4 to 6.
C. close to that of the diamond.
D. greater than that of topaz.
E. less than that of calcite.

133. (1.10) A clastic rock may be

A. a conglomerate. **B.** an igneous intrusion.
C. a granite gneiss. **D.** a schist.
E. a metamorphic granite.

134. (1.10) Which one of these is formed from deposits of undissolved mineral grains of rock particles?

A. Shale. **B.** Rock salt. **C.** Granite.
D. Scoria. **E.** Coal.

Item 135 deleted.

136. (1.10) Which one of these is classed as a rock?

A. Quartz. **B.** Hematite. **C.** Basalt.
D. Galena. **E.** None of the above.

137. (1.10) Petrification of wood involves

- **A.** a compacting of the wood due to great pressures followed by cementation by silica.
- **B.** a slow baking process whereby the clay in the spaces of the wood is hardened.
- **C.** elimination of the woody substances and their replacement with minerals.
- **D.** deposition of minerals in the spaces between the wood fibers.
- **E.** chemical oxidation of soft wood fibers to hard mineral-like substances.

138. (1.10) Metamorphic rock can be formed from magma by which of the following processes?

- **A.** Solidification followed by gradation.
- **B.** Slow cooling beneath the surface.
- **C.** Solidification followed by diastrophism.
- **D.** Solidification followed by volcanism.
- **E.** Rapid cooling above the surface.

139. (1.10) Which one of the following is an intrusive igneous rock?

A. Sandstone. **B.** Granite. **C.** Marble.
D. Obsidian. **E.** Slate.

140. (1.10) Which one of the following rocks is formed mainly by the cementing together of gravel and pebbles?

A. Marble. **B.** Basalt. **C.** Gneiss.
D. Porphyry. **E.** Conglomerate.

141. (1.10) Which one of the following might be formed by the consolidation of weathered clay sediments?

A. Lignite. **B.** Marble. **C.** Porphyry.
D. Shale. **E.** Gneiss.

142. (1.10) Which one of the following features is due primarily to folding of rock strata?

A. An anticline. **B.** A fluvial plain.
C. A batholith. **D.** A sill. **E.** A laccolith.

Items 143 - 149 refer to the properties of minerals. For each item identify the mineral by reference to the key.

KEY

A. Bauxite. **B.** Biotite. **C.** Calcite. **D.** Talc.
E. Limonite.

143. (1.10) The principal cementing agent found in sandstone formations.

144. (1.10) A mineral which feels soapy and is rather flexible but inelastic.

145. (1.10) A hydrous oxide, which is a commercial source of a common lightweight metal.

146. (1.10) A mineral with rhombohedral cleavage in three directions, clear crystals of which can be used optically.

147. (1.10) A mineral with the chemical formula $Al_2O_3 \cdot nH_2O$ which has a clay-like odor.

148. (1.10) A complex silicate, platy or foliated, commonly found in igneous or metamorphic rocks.

149. (1.10) A mineral, generally brown in color, with a streak varying in color from yellow to brown, frequently used as a paint pigment.

Items 150 - 152 refer to the sources of some of our common metals. For each item select from the key the associated ore.

KEY

A. Galena. **B.** Hematite. **C.** Bauxite.
D. Sphalerite.
E. Some ore other than one of the above four.

150. (1.10) An important ore of zinc.

151. (1.10) An important ore of copper.

152. (1.10) An important ore of aluminum.

For items 153 - 157 use the following key to classify each item as to the type of chemical compound.

KEY

A. Carbonate. **B.** Halide. **C.** Oxide.
D. Silicate. **E.** Sulfate.

153. (1.10) Rock salt. **154.** (1.10) Mica. **155.** (1.10) Gypsum.

156. (1.10) Feldspar.

157. (1.10) Quartz (the main constituent of sand).

Items 158 - 161 are minerals. Select from the key the group to which each belongs.

KEY

A. Silicates. **B.** Carbonates. **C.** Sulfates.
D. Halides. **E.** Oxides.

158. (1.10) Quartz. **159.** (1.10) Gypsum. **160.** (1.10) Mica.

161. (1.10) Feldspar.

Items 162 - 166 are rocks which contain certain characteristic minerals. Select from the key the mineral to be found in each.

KEY

A. Feldspar. **B.** Halite. **C.** Calcite.
D. Chlorite. **E.** Hematite.

162. (1.10) Marble. **163.** (1.10) Green slate. **164.** (1.10) Rock salt.

165. (1.10) Granite. **166.** (1.10) Limestone.

For items 167 - 175 select from the key the most appropriate mineral.

KEY

A. Calcite. **B.** Galena. **C.** Hematite.
D. Pyrite. **E.** Quartz.

167. (1.10) Generally white or colorless: hardness about 3.

168. The major constituent of limestone. **169.** Fe_2O_3.
(1.10) (1.10)

170. The commonest of the five minerals.
(1.10)

171. Generally white or colorless; hardness about 7.
(1.10)

172. Streak light red to red-brown.
(1.10)

173. Shows perfect cubic cleavage.
(1.10)

174. Major ore of lead. **175.** Fool's gold.
(1.10) (1.10)

For each item, 176 - 179, select from the key the essential metal characteristic of the mineral given in the item.

KEY

A. Lead. **B.** Copper. **C.** Aluminum.
D. Zinc. **E.** Iron.

176. Hematite. **177.** Bauxite. **178.** Chalcopyrite.
(1.10) (1.10) (1.10)

179. Galena.
(1.10)

For each item, 180 - 182, select from the key the essential metal characteristic of the mineral given in the item.

KEY

A. Lead. **B.** Copper. **C.** Aluminum.
D. Zinc. **E.** Iron.

180. Limonite. **181.** Sphalerite. **182.** Malachite.
(1.10) (1.10) (1.10)

For items 183 - 185 select from the key the metamorphic equivalent of the rocks.

KEY

A. Gneiss. **B.** Slate. **C.** Quartzite.
D. Marble. **E.** Schist.

183. Sandstone. **184.** Granite. **185.** Limestone.
(1.10) (1.10) (1.10)

For items 186 - 191 select from the key the most closely related substance.

KEY

A. Mineral. **B.** Sedimentary rock.
C. Igneous rock. **D.** Metamorphic rock.
E. None of these.

186. Basalt. **187.** Limestone. **188.** Hornblende.
(1.10) (1.10) (1.10)

189. Quartzite. **190.** Slate. **191.** Marble.
(1.10) (1.10) (1.10)

192.

A. Basalt	a. Metamorphic
B. Limestone	b. Sedimentary
C. Marble	c. Igneous

Which of the following choices correctly matches the above rocks and rock classifications?

A. Aa Bb Cc. **B.** Aa Bc Cb. **C.** Ab Ba Cc.
D. Ac Ba Cb. **E.** Ac Bb Ca.

Items 193 - 199 refer to the classification of rocks. For each item select from the key the correct classification.

KEY

A. Igneous, intrusive. **B.** Igneous, extrusive.
C. Metamorphic, foliated.
D. Metamorphic, non-foliated.
E. Sedimentary, clastic.

193. Marble. **194.** Obsidian. **195.** Conglomerate.
(1.10) (1.10) (1.10)

196. Shale. **197.** Gabbro. **198.** Slate.
(1.10) (1.10) (1.10)

199. Granite.
(1.10)

For each item, 200 - 202, select from the key the essential mineral of the rock given in the item.

KEY

A. Quartz. **B.** Kaolin. **C.** Calcite.
D. Halite. **E.** Biotite.

200. Chalk. **201.** Slate. **202.** Chert.
(1.10) (1.10) (1.10)

For each item, 203 - 206, select from the key the rock class to which the rock given in the item belongs.

KEY

A. Intrusive igneous. **B.** Extrusive igneous.
C. Sedimentary. **D.** Foliated metamorphic.
E. Non-foliated metamorphic.

203. Quartzite. **204.** Basalt **205.** Slate.
(1.10) (1.10) (1.10)

206. Shale.
(1.10)

For items 207 - 216 select from the key the class to which each belongs.

KEY

A. Igneous rock. **B.** Metamorphic rock.
C. Sedimentary rock. **D.** Mineral.

207. Quartz. **208.** Gabbro. **209.** Conglomerate.
(1.10) (1.10) (1.10)

210. Orthoclase. **211.** Marble. **212.** Gneiss.
(1.10) (1.10) (1.10)

213. Rhyolite. **214.** Calcite.
(1.10) (1.10)

215. Shale. **216.** Diorite.
(1.10) (1.10)

For items 217 - 219 select from the key the type of rock for which the item is characteristic.

KEY

A. Sedimentary rock. **B.** Igneous rock.
C. Metamorphic rock. **D.** Two of the above.
E. All three rock classes.

217. Glassy. **218.** Slaty cleavage.
(1.10) (1.10)

219. Composed of minerals.
(1.10)

Items 220 - 228 refer to various geologic names. For each item select from the key the most appropriate classification.

KEY

A. Extrusive igneous rock.
B. Intrusive igneous rock. **C.** Sedimentary rock.
D. Metamorphic rock. **E.** None of the above.

220. Halite. (1.10)
221. Scoria. (1.10)
222. Limestone. (1.10)

223. Basalt. (1.10)
224. Obsidian. (1.10)
225. Quartzite. (1.10)

226. Diorite. (1.10)
227. Rock salt. (1.10)
228. Gabbro. (1.10)

For each item, 229 - 233, select from the key the most appropriate response.

KEY

A. Extrusive igneous rock.
B. Intrusive igneous rock. **C.** Metamorphic rock.
D. Mineral. **E.** Sedimentary rock.

229. Marble. (1.10)
230. Rhyolite. (1.10)
231. Schist. (1.10)

232. Muscovite. (1.10)
233. Granite. (1.10)

For each item, 234 - 239, select from the key the rock class to which the rock given in the item belongs.

KEY

A. Intrusive igneous. **B.** Extrusive igneous.
C. Sedimentary. **D.** Foliated metamorphic.
E. Non-foliated metamorphic.

234. Conglomerate. (1.10)
235. Vesicular basalt. (1.10)

236. Granite gneiss. (1.10)
237. Marble. (1.10)

238. Granite porphyry. (1.10)
239. Obsidian. (1.10)

240. Match the minerals listed with the descriptive information by selecting the lettered response which correctly matches them.
(1.10)

Minerals:	Description:
x. quartz.	a. $CaCO_3$.
y. mica.	b. soft mineral that splits in thin sheets.
z. calcite.	c. has a hardness of 7, glassy luster, and shows no cleavage.

A. xa, yb, zc. **B.** xa, yc, zb. **C.** xb, ya, zc.
D. xc, ya, zb.
E. Some other arrangement for matching.

241. Classify the following rocks as to type by selecting the lettered response which correctly matches them.

Rocks:	Type:
x. granite.	a. igneous.
y. limestone.	b. metamorphic.
z. marble.	c. sedimentary.

A xa, yb, zc. **B.** xa, yc, zb. **C.** xb, ya, zc.
D. xc, ya, zb.
E. Some other matching arrangement.

242. Exceedingly slow cooling of magma to form igneous rock results in the formation of
(1.10)

A. dark glassy rock. **B.** layered rock.
C. uniform rock.
D. rock containing large mineral crystals.

243. A rock may be most generally defined as
(1.10)

A. a substance of very definite chemical composition.
B. a substance formed by the hardening of sediments.
C. a homogeneous mixture of two or more elements.
D. a mixture of minerals.

244. One of the most conspicuous features of sedimentary rocks is their
(1.10)

A. crystalline structure.
B. extremely large grain size.
C. glassy appearance. **D.** layered structure.

245. One class of metamorphic rock is
(1.10)

A. limestone. **B.** sandstone. **C.** marble.
D. shale.

246. Metamorphic rock may be identified by the following characteristics.
(1.10)

A. Deformities in the structure.
B. Elongation of rocks.
C. Presence of pores and air holes.
D. reorientation of crystal structure.

247. Sedimentary rocks are formed
(1.10)

A. by consolidation of sand particles.
B. from buried vegetable material.
C. from shells of marine animals.
D. directly from mineral deposits.

248. The atmosphere
(1.10)

A. as a mixture, has a greater specific gravity than oxygen has.
B. contains a larger per cent of argon than of CO_2.
C. contains no element which reacts with heated magnesium.
D. is completely insoluble in water.
E. is the principal source of commercial hydrogen.

249. Judging by the composition of the earth's outer crust, which one of the following compounds would probably occur most commonly in the earth's crust?
(1.10)

A. $MgCl_2$. **B.** SiO_2. **C.** CuO. **D.** NaO.
E. NaCl.

250. Three and only three of the following minerals are possessed by the United States in sufficient quantity for present needs, with possible surplus for export.
(1.10)

a. Bauxite. b. Bituminous coal. c. Iron.
d. Manganese. e. Sulfur.

The three possessed by the United States in sufficient quantity are

A. a, b, and c. **B.** b, c, and e. **C.** a, b, and e.
D. c, d, and e. **E.** b, c, and d.

251. A metamorphic rock is defined as:
(1.10)

A. a pre-existing rock that has been altered by heat and pressure.
B. a rock consisting of altered sediments.
C. a rock of high specific gravity with visible mineral grains.
D. a rock consisting of crushed fragments or folded pre-existing rocks cemented by primary minerals.
E. a pre-existing rock that has been deformed by extreme pressure produced by faulting.

252. Which physical property best describes "lodestone"?
(1.10)

A. 2 directions of cleavage.
B. Reddish-yellow color. **C.** Cubic crystal form.
D. Glassy luster. **E.** Magnetism.

253. Select the correct definition of a mineral.
(1.10)

A. A naturally occurring substance bounded by smooth faces.
B. A chemical combination of naturally occurring inorganic and/or organic materials.
C. A naturally occurring substance composed of two or more elements that are formed by heat, pressure, and precipitation.
D. A naturally occurring substance possessing definite chemical composition and physical properties.
E. A natural solid substance possessing definite streak, perfect cleavage, and variable specific gravity.

254. Which of these geological processes is most important in concentrating ore deposits?
(1.10)

A. Formation of glacial till.
B. Deposition of marine sediments.
C. Deposition of wind-blown sands.
D. Emanation of gases from volcanoes.
E. Deposition of non-marine shales.

255. The dominant minerals of the earth's crust are
(1.10)

A. silicates. **B.** organic compounds. **C.** oxides.
D. native elements. **E.** sulfides.

256. Which statement represents the correct definition of a rock?
(1.10)

A. A naturally occurring substance with definite physical properties.
B. An accumulation of organic material.
C. An aggregate of one or more minerals.
D. A material with definite cleavage and streak.
E. Material which cooled and solidified from a molten state.

257. Select the statement concerning *cleavage*, which is *incorrect*.
(1.10)

A. A plane along which crystals break easily.
B. A plane that reflects light.
C. It is due to atomic structure.
D. It is a characteristic of both kinds of feldspar.
E. It is well developed in quartz.

258. The great lava plateaus of the world such as the Deccan lava flows of India and the Columbia River lava flows, consist of which rock type?
(1.10)

A. Obsidian. **B.** Felsite. **C.** Granite.
D. Basalt. **E.** Volcanic breccia.

259. An intrusive rock is
(1.10)

A. a metamorphic rock found in mountain regions.
B. a sedimentary rock that has been altered by a dike or sill.
C. a rock derived from magma that cooled before reaching the surface.
D. a volcanic rock that cooled slowly and is not affected by erosion.
E. an igneous rock that is composed largely of clastic material.

260. A certain rock is described as being vesicular, dark-colored, and is found near an active volcano. This rock is
(1.10)

A. tuff. **B.** scoria. **C.** basalt.
D. basalt porphyry. **E.** felsite.

261. Select the rock that cooled most rapidly from the molten state.
(1.10)

A. Granite. **B.** Syenite. **C.** Felsite.
D. Obsidian. **E.** Gabbro.

262. The evidence that suggests that the rock selected in the question above cooled most rapidly is
(1.30)

A. the groundmass consists of feldspar.
B. crystals of olivine settled to the bottom.
C. it is composed of quartz and feldspar.
D. large crystals were formed.
E. no crystals developed.

263. Which of the following pair of mineral and derived metal is not true?
(1.10)

A. Galena-lead. **B.** Hematite-iron.
C. Gold-gold. **D.** Pitchblende-uranium.
E. Chalcopyrite-zinc.

264. Salt domes are
(1.10)

A. accompanied by intrusion of granites.
B. prominent in the Tertiary rocks of the Gulf Coast of Texas and Louisiana.
C. poor areas to prospect for petroleum.
D. found in rocks of all ages.
E. always covered by younger salt beds.

265. Which one of the following contains no aluminum?
(1.10)

A. Corundum. **B.** Cryolite. **C.** Clay.
D. Sapphire. **E.** Hematite.

266. The transformation of wood into hard coal involves some of the following stages:
(1.22)

a. Anthracite. b. Bituminous. c. Graphite.
d. Coke. e. Lignite. f. Peat.

A correct sequential list of the actual stages would be

A. c, b, e, d. **B.** f, b, a, d, e. **C.** f, e, b, a.
D. e, f, c, a. **E.** f, d, e, b, a.

267. Assume that you could walk the entire length of a living
(1.22) valley glacier from the melting end to the headwall of the cirque. Which of the following would you come to first?

A. Bergschrund. **B.** Lateral moraine.
C. Ablation moraine. **D.** Arrete.
E. Ground moraine.

268. Metamorphic rocks are those rocks which
(1.23)

A. have cooled and solidified from molten material.
B. have been produced from existing rocks by weathering.
C. have undergone a partial change from their original state by means of heat and pressure.
D. are formed from sedimentary rocks only.
E. are formed from igneous rocks only.

269. Sulfides, carbonates, and silicates, in the study of geol-
(1.23) ogy, are properly classed as

A. igneous rocks. **B.** hydrates. **C.** minerals.
D. clastic sediments. **E.** metamorphic rocks.

For items 270 - 274 choose from the key the class of rock that would possess the characteristics to the most marked degree.

KEY

A. A characteristic common to two of the following three.
B. Igneous. **C.** Metamorphic. **D.** Sedimentary.

270. May be composed of undissolved mineral grains or pre-
(1.23) cipitated salts.

271. May exhibit the characteristic of bedding.
(1.23)

272. Crystalline texture may range from microscopic to glassy.
(1.23)

273. May include clastic type rocks.
(1.23)

274. May be of either intrusive or extrusive origin.
(1.23)

275. Chemical alteration and recrystallization is characteristic
(1.23) of rocks classified as

A. igneous. **B.** metamorphic. **C.** sedimentary.
D. two of the above. **E.** three of the above.

276. In geology, sulfides, carbonates, and silicates are prop-
(1.23) erly classed as

A. igneous rocks. **B.** hydrates. **C.** minerals.
D. clastic sediments. **E.** metamorphic rocks.

277. All samples of granite gneiss and marble are alike in
(1.23) that they are

A. foliated. **B.** of the same composition.
C. volcanic in origin. **D.** metamorphic.
E. igneous extrusions.

Items 278 - 288 refer to rocks and their classification. For each item select from the key the appropriate classification.

KEY

A. Igneous only. **B.** Metamorphic only.
C. Sedimentary only.
D. Both igneous and metamorphic.
E. Igneous, metamorphic, and sedimentary.

278. Rocks, the material of which is derived from the weather-
(1.23) ing and erosion of pre-existing rocks and is held together by a cementing material.

279. The classification of basalt, marble, and red slate.
(1.23)

280. Rocks often called primary because they are formed
(1.23) from material which originated in the deeper portions of the earth.

281. Rocks to which descriptive terms such as felsitic, por-
(1.23) phyritic, or pegmatitic are applied in their identification.

282. Rocks in which one may find quartz.
(1.23)

283. Rocks which are often named gneisses and schists.
(1.23)

284. A rock class in which a glassy texture is sometimes
(1.23) found.

285. Rocks which contain platy minerals, such as mica or
(1.23) chlorite, in parallel arrangement so that the rock may be split readily.

286. Rocks which are formed through mineral and textural
(1.23) alterations of pre-existing rocks.

287. Rocks in which cross-bedding is frequently found.
(1.23)

288. Rocks in which ground water may form caverns.
(1.23)

Items 289 - 297 are descriptive of rocks on the basis of their origin. For each item select from the key the class of rocks to which it is related.

KEY

A. Igneous. **B.** Metamorphic. **C.** Sedimentary.
D. Two of the above. **E.** Three of the above.

289. Foliated such as the gneisses.
(1.23)

290. Composed largely of complex silicate minerals.
(1.23)

291. Hardened through cementation and pressure.
(1.23)

292. An aggregate of minerals constituting a significant por-
(1.23) tion of the lithosphere.

293. The bulk of them composed of minerals that are stable
(1.23) under conditions existing at the earth's surface.

294. Altered chemically and recrystallized.
(1.23)

295. Solidification of magma.
(1.23)

296. Non-porous and crystalline, generally hard unless com-
(1.23) posed of soft minerals.

297. Glassy in texture.
(1.23)

298. The three fundamental categories into which rocks are
(1.23) classified are based on their

A. chemical composition. **B.** origin.
C. hardness. **D.** age.

299. Rocks are classified as igneous, sedimentary, or meta-
(1.23) morphic because these classifications are

A. convenient. **B.** traditional. **C.** conditional.
D. unique.

Items 300 - 306 refer to some of the methods used to identify minerals. For each item select from the key the most appropriate response.

KEY

A. Chemical tests.
B. Cleavage or examination of crystalline faces.
C. Characteristic odor after striking the specimen.
D. Structure. **E.** Tests of hardness.

300. A confirmatory test for an earthy specimen you believe
(1.24) to be kaolin.

301. A valuable aid to the identification of mica.
(1.24)

302. The most satisfactory field test for distinguishing calcite
(1.24) from quartz.

303. Aside from color, a physical identification which one
(1.24) would certainly make in distinguishing galena from calcite.

304. An identification involving a property common to
(1.24) asbestos.

305. A test very likely to be used in distinguishing fluorite
(1.24) from gypsum.

306. A test most likely to be used in identifying limestone.
(1.24)

307. On a ridge east of Hanover at a site known as "prexy's
(1.24) Garden," a granite boulder some 15 feet long and 6 feet high rests so unstably on the granite ledge that it can be rocked "like a cradle." If this boulder is an erratic you could prove that fact by all except one of the following statements. Which one is the exception?

A. It is subangular and shows polished surface.
B. It is of a different kind of granite from the ledge itself.
C. Both ledge and boulder show striae.
D. Neither the boulder nor the ledge show much weathering.
E. The sides of the boulder correspond in their position to the position of joints in the ledge below.

308. Which of the following geological conditions is not a
(1.24) prerequisite for an old field?

A. The presence of a suitable trap.
B. The presence of source beds.
C. Bedrock must be exposed at the surface.
D. Lack of regional metamorphism.
E. Marine sedimentary rocks must be present in the geologic column.

309. In a roadside cut which exposes both mantle and bed-
(1.24) rock you could recognize the mantle as residual

A. if the boulders in the mantle were fresh rock and showed no gradation in size from the surface to the bedrock.
B. if the boulders in the mantle were smaller near the surface and larger nearer the bedrock, and in both cases had a core like that of the bedrock although they were somewhat weathered on the outside.
C. if there was a sharp clear contact between the mantle and the bedrock.
D. if the stones and boulders in the mantle were soled and had scratches on their surfaces.
E. none of the above.

310. Suppose you were given two specimens of granite, one
(1.24) of them definitely a result of long-time transport by streams; the other definitely had been dragged along in the bottom of the ice sheet and left when the ice melted. They are about the same in size, about as large as your fist. You could tell the difference between the two because

A. the stream pebble would have a brown coating on its surface while the ice-borne one would show fresh rock.
B. the ice-borne pebble would probably show signs of weathering by solution while the stream pebble would show none.
C. the stream pebble would probably be somewhat heavier having absorbed water during its transport while the ice-borne pebble would have all water squeezed out by weight of the ice.
D. the stream pebble would be well rounded while the ice-borne one would be subangular and might show striae.
E. the difference in appearance would not permit any distinction whatsoever to be made.

311. During the process of magmatic differentiation of basalt,
(1.30) which mineral crystallizes first?

A. Amphibole. **B.** Plagioclase. **C.** Pyroxene.
D. Olivine. **E.** Quartz.

312. A rock had the following characteristics: stratified and
(2.10) non-calcareous, composition largely kaolin, low permeability, easily broken into thin plates, and minute pore spaces. The rock would most likely be

A. limestone. **B.** coal. **C.** shale.
D. conglomerate. **E.** sandstone.

313. Asbestos occurs as an aggregate thread-like *fibrous*
(2.10) mineral. The word *fibrous* refers to

A. fracture. **B.** structure. **C.** lustre.
D. cleavage. **E.** hardness.

314. The "horse backs" that are exposed in strip mines were
(2.10)

A. probably ditches caused by water erosion.
B. gaps resulting from earth crystal disturbances.
C. pre-historic man-made ditches that were finally filled with clay.

Items 315 - 318 refer to the four minerals described as follows:

1. The first mineral fizzes when hydrochloric acid is placed upon it.
2. The second mineral is colorless and has a hardness of 10.
3. The third mineral is white and consists of easily separable but inelastic scales or plates. It has a hardness of 1.
4. The fourth mineral has a metallic luster, cubic cleavage, and is a sulphide.

315. The first mineral
(2.10)

- **A.** is a major constituent of granite.
- **B.** is a major ore of zinc.
- **C.** is generally used as a ring stone.
- **D.** has rhombic cleavage, and can be scratched with a knife.
- **E.** is common in cooled lava.

316. The second mineral
(2.10)

- **A.** when burned in oxygen leaves no ash.
- **B.** is a major ore of aluminum.
- **C.** has well-developed conchoidal fracture.
- **D.** is commonly used as an abrasive in tooth paste and cleaning powders.
- **E.** is used as a filler in paint.

317. The third mineral
(2.10)

- **A.** has a formula of NaCl.
- **B.** is used to make plaster of Paris.
- **C.** is a major ore of iron.
- **D.** is usually found in abundance in the residue of evaporated sea water.
- **E.** is soapy to the touch.

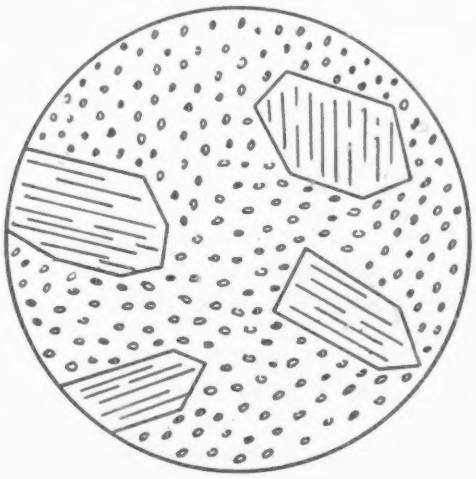
318. The fourth mineral
(2.10)

- **A.** has a formula of ZnS.
- **B.** is metallic and yellow in color.
- **C.** is a major ore of lead.
- **D.** has a specific gravity of .5.
- **E.** is the second most common mineral.

319. In a Chicago quarry the walls are thick horizontal layers of a pale gray rock which contains many tiny shells of marine animals. It dissolves slowly in water containing carbon dioxide. It is probably
(2.10)

A. limestone. **B.** granite. **C.** basalt.
D. sandstone. **E.** shale.

Diagram G



320. Diagram G illustrates diagrammatically that type of rock texture termed
(2.10)

A. granitic. **B.** porphyritic. **C.** pegmatitic.
D. felsitic. **E.** glassy.

For items 321 - 325 blacken the *one* lettered space which designates the correct answer.

A rock formation has the following characteristics:

1. It is white and has a crystalline structure.
2. It is largely composed of calcium carbonate.
3. It is not a sedimentary rock.
4. It contains no fossils.

321. The information listed above indicates that the rock is
(2.10)

A. limestone. **B.** sandstone. **C.** marble.
D. granite. **E.** none of these.

322. The information listed above also indicates that the rock is
(2.10)

A. igneous. **B.** metamorphic. **C.** unstratified.
D. near the earth's surface. **E.** a part of an intrusion.

323. From the information given and other knowledge it is legitimate to conclude that the rock was originally
(2.10)

A. shale. **B.** conglomerate. **C.** sandstone.
D. limestone. **E.** gravel.

324. One can also infer from the information given that one might find near this rock
(2.10)

A. an igneous intrusion. **B.** layers of sandstone.
C. faults. **D.** talus. **E.** an unconformity.

325. The reason that there are no fossils in this rock is that
(2.10)

- **A.** such rocks were formed when no plant or animal life yielding fossils existed.
- **B.** fossils are not found in rocks of this chemical composition.
- **C.** heat and pressure destroys fossils.
- **D.** weathering destroys fossils.

326. A coarse gravel with rounded edges, cemented together to make a rock indicates
(2.10)

327. Metamorphic rock in general indicates
(2.10)

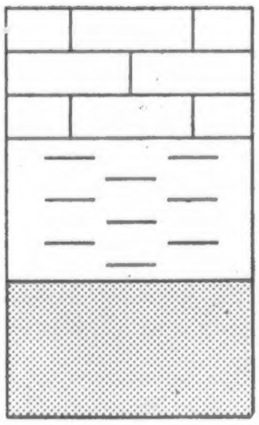
- **A.** that heat and pressure have altered pre-existing rock.
- **B.** that slow-flowing water deposited the material.
- **C.** that water flowing out of high mountains from what may have been a cool climate deposited the material, probably under water.
- **D.** that a volcano produced the material.
- **E.** that a glacier produced the material.

328. Estimate roughly the atmospheric pressure on a mountaintop 8000 feet in elevation above sea level. In pounds per square inch, it is approximately
(2.10)

A. 7. **B.** 9. **C.** 10. **D.** 11. **E.** 12.

329. Which sequence of rocks is shown by the columnar section on the next page? (bottom to top)
(2.10)

- **A.** Shale, sandstone, limestone.
- **B.** Limestone, shale, sandstone.
- **C.** Sandstone, limestone, shale.
- **D.** Sandstone, shale, limestone.
- **E.** Slate, limestone, sandstone.



330. (2.20) Refer to the columnar section in the question 329. How would you interpret this section of rocks?

- **A.** Deposits laid down in regressing sea.
- **B.** A regression followed by a transgression of the sea without metamorphism in the lower zone.
- **C.** Deposits of Pennsylvanian sandstone and slate overlain by Permian limestone.
- **D.** Deposits of marine sedimentary rocks intruded by non-marine shales.
- **E.** Deposits laid down in a transgressing sea.

331. (2.20) An exposure of rock which was examined had characteristics as follows: Yellowish brown color, porous structure, beds of uniform thickness which were distinguished by changes of grain size, uniform composition with quartz the only mineral identified. The origin of this rock

A. was volcanic. **B.** was metamorphic.
C. was sedimentary. **D.** was igneous.
E. cannot be determined without additional information.

332. (2.30) A concentrated sugar solution cooled slowly allowing large clear crystals to form on the sides of the container. These crystals were mixed in with the remaining syrup and the entire mass cooled rapidly. Rocks similarly formed would most probably be characterized as

A. felsitic. **B.** glassy. **C.** granitic.
D. pegmatitic. **E.** porphyritic.

333. (2.40) It is thought by some people that the center of the earth is composed of molten material because

- **A.** direct P waves are not recorded by seismographs situated half way around the earth from the epicenter.
- **B.** the speed of earthquake waves increases when those waves reach a depth of about 10 miles or more below the surface.
- **C.** P and S waves travel the chord of the arc while L waves do not.
- **D.** direct S waves are not recorded on seismographs at a distance of a little more than a third of the way around the earth from the epicenter.
- **E.** S waves are the type which are not transmitted through liquids.

Items 334 - 337 are to be answered by selecting the correct statement from the following key.

KEY

- **A.** Alteration due to heat and pressure.
- **B.** Deposition due to precipitation from solutions.
- **C.** Replacement due to gases from lava flow.
- **D.** Cooling of magma.
- **E.** Precipitation of sandstone.

334. (2.40) Refer to the key. Which statement best describes a process by which a sedimentary rock could be formed?

335. (2.40) Which statement best describes a process that results in regional metamorphism?

336. (2.40) Which statement best describes a process by which an igneous rock could be formed?

337. (2.40) Which statement best describes a non-existent geological process?

338. (4.20) A student reporting his findings for a certain mineral specimen stated the following:

1. Hardness 3.
2. Splits with perfect cleavage in three directions (not at right angles).
3. Non-metallic luster.
4. Light streak.
5. Breaks unevenly.
6. Blocky.

His instructor marked 5 as incorrect (inconsistent) because

- **A.** a mineral which breaks unevenly has conchoidal fracture.
- **B.** a non-metallic mineral should be earthy rather than uneven.
- **C.** blocky minerals have no tendency to break.
- **D.** a mineral with perfect cleavage shows no fracture.
- **E.** a mineral with a hardness of 3 crumbles rather than breaks unevenly.

339. (2.10) The mineral described in the preceding item was

A. calcite. **B.** galena. **C.** halite. **D.** chlorite.
E. kaolin.

Items 340 - 344 refer to the following *observations* of a specimen of rock:

1. The rock is light colored.
2. It is composed of large crystals, easily visible to the unaided eye.
3. It contains appreciable amounts of quartz and feldspar minerals.

For each item select from the key the most appropriate response.

KEY

- **A.** If observation *1* contradicts the statement.
- **B.** If observation *2* contradicts the statement.
- **C.** If observation *3* contradicts the statement.
- **D.** If observation *1*, *2*, and *3* contradict the statement.
- **E.** If none of the observations contradicts the statement.

340. (4.20) The rock may be granite.

341. (4.20) The rock may be sandstone.

342. (4.20) The rock may be rhyolite.

343. (4.20) The rock may have been formed in the surface environment.

344. (4.20) The rock, while forming, cooled very slowly.

Items 345 - 350 are based on the following three facts concerning a series of sedimentary rocks making up a cliff.

1. The series is represented by an underclay, above which lies a thick coal seam. On top of the coal seam is a limestone bed.
2. The sediments have not been overturned (they are as originally deposited).
3. A normal fault cuts the strata.

For each item select from the key the most appropriate response.

KEY

- **A.** Based on (1) the statement is true.
- **B.** Based on (2) the statement is true.
- **C.** Based on (3) the statement is true.
- **D.** Based on statements (1), (2), and/or (3) the statement is false.
- **E.** No evidence given in (1), (2), or (3) by which the statement can be judged.

345. (4.20) Volcanic action took place at one time in the past.

346. (4.20) The region was subjected to horizontal tensional forces.

347. (4.20) The climate during part of the time of deposition was warm.

348. (4.20) The land during deposition was slowly raised above sea level, eroded, lowered slightly and finally raised a second time.

349. (4.20) Differential movement of the crustal blocks occurred at some time after deposition.

350. (4.20) The lowest bed of the series is the youngest.

For items 351 - 355 select from the key the most appropriate response.

KEY

- **A.** The statement is true and the reason given is valid.
- **B.** The statement is true but the reason is invalid.
- **C.** The statement is false.

351. (4.20) Quartzite, a metamorphic rock, is quite porous because it is formed from sandstone which is a porous sedimentary rock.

352. (4.20) When a rock reacts with dilute HCl, it is not necessarily sedimentary because some metamorphic rocks could produce the same reaction.

353. (4.20) A piece of black glassy obsidian contains only dark minerals because in its formation from magma it cooled too rapidly for other crystals to separate out.

354. (4.20) A sheet of white paper ruled with blue lines appears red when viewed in red light but the lines appear black because white can absorb red radiation but blue can only absorb blue.

355. (4.20) Physical rather than chemical devices had to be used to separate the isotopes of uranium for use in atomic energy because isotopes are chemically the same element.

356. (4.20) In the statement: The lithosphere at a depth of 24 miles must be molten because the temperature rises 1° centigrade for approximately every 100 feet of depth,

- **A.** the first part of the statement is true, and its truth is supported by the reason given in the statement.
- **B.** the first part is true, but its truth is *not* supported by the reason given.
- **C.** the first part of the statement is false.

357. (4.20) Which one of the following features is more prominent for what is missing than for what is present?

A. Fault. **B.** Unconformity. **C.** Batholith.
D. Anticline. **E.** Footwall.

358. (4.20) Which one of these is unrelated to the others?

A. Basalt. **B.** Slate. **C.** Schist. **D.** Gneiss.
E. Quartzite.

359. (4.20) Various terms are applied to describe the character of the light reflected from the surface of a mineral. Which word includes all the others?

A. Lustre. **B.** Earthy. **C.** Vitreous. **D.** Pearly.
E. Metallic.

360. (4.20) A rock may be distinguished from a mineral in that a rock

- **A.** has definite chemical composition and characteristic properties.
- **B.** is sometimes a free element.
- **C.** is an aggregate of discrete particles packed together or ingrown.
- **D.** is always a chemical compound rather than a mixture.
- **E.** is always formed from liquid material from the interior of the earth.

361. (4.20) The *usual* definition of a mineral would prohibit the inclusion of which one of the following as a mineral?

A. Lava. **B.** Rock Salt. **C.** Ice. **D.** Graphite.
E. Copper.

362. (4.20) A student report on a mineral showed the following:

1. Hardness: 7.
2. Cleavage: perfect cubic.
3. Luster: non-metallic, vitreous.
4. Streak: white to gray.
5. Color: colorless or tints of white, gray, to pink.
6. Fracture: conchoidal.
7. Structure: massive.

His instructor marked 2 as *incorrect* because

- **A.** any mineral with a hardness of 7 could have no cleavage.
- **B.** if the specimen has conchoidal fracture, it cannot have perfect cubic cleavage too.
- **C.** a mineral with massive structure cannot have perfect cleavage.
- **D.** from the rest of the data, the cleavage should have been in one direction.
- **E.** the structure would have to be earthy in order to have perfect cleavage.

363. (2.10) The mineral described in item 362 is probably

A. calcite. **B.** halite. **C.** quartz. **D.** chlorite.
E. galena.

Directions: The following statements are followed by three true statements and one false statement. On your answer sheet darken the space under the number which in your opinion is the false statement.

364. (4.20) Since sedimentary rocks are formed from pre-existing rocks, their structure and composition depend on the following factor:

A. Composition of the source material.
B. Sorting power of the transportation agents: wind and water.
C. The ability of the sediment to harden.
D. Great pressures and high temperatures.

365. (6.20) Which one of these is the *poorest* characteristic for distinguishing sedimentary rocks from the other classes?

A. Bedding. **B.** Color. **C.** Fossils.
D. Ease of breakage. **E.** Porosity.

366. (6.20) Which rock types are most important in the Hanover region?

A. Flat lying sedimentary rocks.
B. Folded and faulted unmetamorphosed sedimentary rocks.
C. Black, marine shales and sandstone.
D. Interbedded limestones and shales.
E. Chlorite and amphibole schists and quartzite.

7. *Land Forms and Water*

8

LAND FORMS AND WATER

1. (1.10) Which one of these is *not* characteristic of a youthful stage of stream development?

A. The land surface is thoroughly dissected and there is a maximum amount of slope land.
B. Down-cutting is dominant because the streams are not fully loaded.
C. The valleys are V-shaped with bottoms only as wide as the channels.
D. The streams have high gradients and relatively straight courses.
E. The land surface has some poorly drained areas not transected by valleys.

Items 2 - 5 constitute a series. For each statement blacken the appropriate answer space according to the following category:

A. The statement is in general true only for youthful streams.
B. The statement is in general true for mature but not for youthful streams.
C. The statement is in general true for both youthful and mature streams.
D. The statement is *not* in general *true* for either youthful or mature streams.

2. (1.10) The stream cuts its channel on the sides.

3. (1.10) Material is deposited on the valley floor.

4. (1.10) The stream meanders broadly and regularly in a valley several times the width of the stream.

5. (1.10) The rate of down-cutting consistently exceeds the rate of side-cutting.

6. (1.10) Debris which collects at the base of a cliff as a result of weathering is called

A. lava. **B.** talus. **C.** kame. **D.** esker.
E. dunes.

7. (1.10) The disintegration of rock in more or less thin layers, a "shelling off" process, is known as

A. diastrophism. **B.** metamorphism.
C. differential erosion. **D.** ex-foliation.
E. abrasion.

8. (1.10) One difference between an old, winding stream and one which has been rejuvenated is

A. the former has tributaries while the latter does not.
B. the former flows faster than the latter.
C. the former has more of the characteristics of a youthful stream than the latter.
D. the former has a steeper gradient than the latter.
E. the former is less apt to have entrenched meanders than the latter.

9. (1.10) A shoreline which has recently emerged is characterized by

A. many indentations and promontories.
B. extensive cliffs and huge, projecting rock ledges.
C. a flat coastal plain.
D. numerous bays and inlets.
E. the same features as a shoreline of submergence.

10. (1.10) A hanging valley

A. results from diastrophism.
B. is produced by a waterfall.
C. is produced by the deposition of rock in a dried-out river bed.
D. results when the ice recedes from a tributary glaciated valley which has not been gouged out as deeply as the main glaciated valley.
E. results from the action of sub-surface water.

11. (1.10) The most logical explanation of the formation of ox-bow lakes is

A. the persistence of lagoons upon the emergence of shorelines.
B. the straightening out (cutting through) of an old meandering river thereby leaving remnants of the old meanders.
C. underground springs oozing towards the surface.
D. geologic changes in climate causing a formerly rainy region to become relatively dry.
E. the melting of glaciers.

12. (2.30) A river which has many well-developed tributaries and which shows lateral erosion would also be expected to be characterized by

A. extensive falls and rapids. **B.** V-shaped walls.
C. a very steep gradient.
D. few, very broad and sharply-cut divides.
E. comparatively numerous, narrow, well-rounded divides.

13. (2.40) A coast line which presents many deep bays and long promontories most likely has recently been subjected to

A. emergence. **B.** submergence.
C. action of waves and shore currents.
D. action of agents of degradation.
E. excessive deposition of sediments.

14. (1.10) Ground water will have a solvent effect on limestone if

A. it contains dissolved salts.
B. it becomes heated up.
C. it contains dissolved carbon dioxide.
D. it is under a high pressure.
E. it is cooled to about 4°C.

15. (1.10) Aggradation refers to

A. the "building-up" process resulting from the deposition of material eroded elsewhere.
B. the "building-up" process resulting from the diastrophism.
C. the "building-up" process resulting from vulcanism.
D. the degradation of mountains.
E. any action of the agents of gradation.

16. The difference between a moraine and an esker
(1.10)

A. a moraine is formed by glacial action whereas an esker has no connection with glaciers.
B. moraines are produced only when glaciers melt but eskers result from the sheering force of a moving glacier.
C. a moraine is made up of igneous rocks whereas an esker is formed of sedimentary rock.
D. moraines are ridges of rock debris deposited at the sides or ends of glaciers, whereas eskers are ridges deposited by sub-glacial streams.
E. moraines may be terminal or lateral, but eskers are only lateral.

17. Which of the following best illustrates the deposition
(1.10) of calcarious material as a result of the evaporation and loss of carbon dioxide from sub-surface water?

A. Caves and sinkholes. B. Talus.
C. Stalactites and stalagmites.
D. Alluvial deposits. E. Dikes and sills.

18. A river which possesses the following topographic char-
(2.10) acteristics: V-shaped valleys with steep walls, few short tributaries, high downward gradient, and many rapids and falls, is said to be in the stage of

A. youth. B. maturity. C. old age.
D. peneplain. E. flood stage.

19. One difference between loess and talus is
(1.24)

A. one is the result of aggradation, the other of degradation.
B. loess may be transported hundreds of miles before deposition whereas talus collects at the base of a cliff.
C. loess is deposited by water but talus is deposited by wind.
D. loess is the product of the action of ground water and talus the product of surface action.
E. one is erosional and the other a depositional form.

20. When a glaciated valley is submerged by the sea it is
(1.10) called

A. delta. B. alluvial fan. C. flood plain.
D. sinkhole. E. fjord.

21. When wave currents carry fine material and deposit it
(1.10) at the entrance of bays thereby tending to close them off, the depositional form is called

A. bar. B. spit. C. tombolo.
D. marginal slope. E. continental shelf.

Items 22 - 36. From the key select the gradational agent which can most closely be associated with each of the items:

KEY

A. Atmosphere (wind, sun, etc.).
B. Surface (running) water-excluding shore agents.
C. Subsurface (ground) water.
D. Sea or shore agents.
E. Glaciers.

22. Till. (1.10)
23. Rills and rivulets. (1.10)
24. Geodes. (1.10)
25. Meanders. (1.10)
26. Tombolos. (1.10)
27. Crevasses. (1.10)
28. Artesian wells. (1.10)
29. Dunes. (1.10)
30. Concretions. (1.10)
31. Cirques. (1.10)
32. Petrified wood. (1.10)
33. Striae. (1.10)
34. Sea cliff. (1.10)
35. Canyons. (1.10)
36. Sinkholes. (1.10)

37. During protracted dry spells, deep-rooted plants may
(1.10) obtain a limited supply of water from the fringe immediately above the water table. This water is obtained directly from the ground water supply and moves upward against the force of gravity because of

A. cohesive force. B. viscosity.
C. capillary action. D. Pascal's principle.
E. Bernoulli's principle.

38. Deflation, as used in geology, refers to the
(1.10)

A. downwarping of the earth's crust.
B. development of peneplanes by streams.
C. leveling effect of a continental glacier.
D. removal of material lying at the surface by wind.
E. development of sinkholes by ground water solution.

39. Talus deposits which accumulate at the base of cliffs
(1.10) were most probably transported to their present position by

A. rivers. B. glaciers. C. oceans. D. winds.
E. gravity.

40. Silt and mud deposited parallel to a river when it over-
(1.10) flows form ridges called

A. eskers. B. dikes. C. monoclines.
D. natural levees. E. deltas.

41. Which one of the following highland landforms may be
(1.10) formed by faulting in the earth's crust?

A. Synclinal valley. B. Block mountain.
C. Anticlinal mountain. D. Laccolithic dome.
E. Monadnock.

42. A. Esker ridge — a. Volcanism
(1.10) B. Anticline — b. Diastrophism
C. Laccolith — c. Gradation

Which of the following correctly matches the above?

A. Aa Bb Cc. B. Aa Bc Cb. C. Ab Ba Cc.
D. Ac Bb Ca. E. Ac Ba Cb.

43. All of the following determine the amount of water
(1.10) absorbed by the ground *except*

A. rate of rainfall. B. porosity of the soil.
C. amount of vegetation. D. slope of the surface.
E. none of the above.

44. Stalactites are usually found in a region where the pri-
(1.10) mary type of erosion is due to

A. volcanism. B. diastrophism. C. winds.
D. ground water. E. surface water.

45. (1.10)

A. Syncline	a. Scraped
B. Cirque	b. Deposited
C. Alluvial fan	c. Folded

Which of the following choices correctly matches the above?

A. Aa Bb Cc. **B.** Aa Bc Cb. **C.** Ab Ba Cc.
D. Ac Bb Ca. **E.** Ac Ba Cb.

46. (1.10)

A. Sink-hole	a. Drift
B. Moraine	b. Granite
C. Laccolith	c. Limestone

Which one of the following choices matches the above?

A. Aa Bb Cc. **B.** Aa Bc Cb. **C.** Ab Ba Cc.
D. Ac Bb Ca. **E.** Ac Ba Cb.

47. (1.10) The present shape of the Great Lakes is chiefly due to

A. down-warping of the earth's crust.
B. glacial gouging of rock strata of varying hardness.
C. water from the melting glacier.
D. alternate elevation and submergence of the region.
E. side-slipping of the Niagara limestone from Niagara Falls to Lake Michigan.

48. (1.10) Which of the following is usually at a maximum when a river has reached the stage of maturity?

A. Breadth of flood plain. **B.** Downward gradient.
C. Steepness of valley walls.
D. Number of tributaries. **E.** Breadth of divides.

For items 49 - 59 select the most appropriate response from the key.

KEY

A. Characteristic of a young river system.
B. Characteristic of a mature river system.
C. Characteristic of an old river system.

49. (1.10) Maximum number of tributaries.

50. (1.10) Eroded to sharply defined divides.

51. (1.10) Vigorous lateral erosion.

52. (1.10) Numerous canyons and waterfalls.

53. (1.10) Broad, high divides.

54. (1.10) Numerous oxbow lakes.

55. (1.10) Potholes.

56. (1.10) The Grand Canyon of the Colorado River.

57. (1.10) Few short tributaries.

58. (1.10) Low gradient and sluggish streams.

59. (1.10) Most nearly complete surface drainage.

60. (1.10) Canyons and waterfalls in stream development are characteristic of

A. maturity. **B.** old age. **C.** youth.
D. two of these. **E.** all of these.

61. (1.10) The movement of water upward from the ground water table for a short distance is due to

A. viscosity. **B.** surface tension.
C. Pascal's principle. **D.** Bernoulli's principle.
E. artesian pressure.

62. (1.10) Mountain building is associated with

A. isostasy. **B.** folding of sediments.
C. accumulation of sediments in a geosyncline.
D. two of the above. **E.** three of the above.

Items 63 - 65 refer to various geologic features of the earth. For each item select from the key the agency usually ascribed as responsible for these features.

KEY

A. Deposition. **B.** Diastrophism. **C.** Erosion.
D. Igneous intrusion. **E.** Igneous extrusion.

63. (1.10) Anticlines and faults.

64. (1.10) Hanging valleys and fjords.

65. (1.10) Moraines and flood plains.

66. (1.10) One of the best evidences of glacial action in a region would be shown by

A. talus heaps at the foot of rock walls.
B. undercutting. **C.** erratics.
D. cross bedding. **E.** exfoliation.

67. (1.10) Cirques are

A. developed in water-eroded valleys.
B. developed by the plucking action of mountain glaciers.
C. dust bowls formed by the wind action in dust storms.
D. formed at the foot of canyon walls in youthful valleys.
E. developed largely by the action of mountain lakes.

68. (1.10) The stage of development of a stream when the land surface is thoroughly dissected and there is a maximum of slope land is known as

A. youthful. **B.** old. **C.** mature.

Items 69 - 74 are matching questions, for example, matching land forms with the agencies causing them; rock names with type of rock; identifying minerals from descriptions and so forth. For each item select from the key the correct pairing sequence of those on the left with those on the right.

KEY

A. X - A; Y - B; Z - C. **B.** X - A; Y - C; Z - B.
C. X - B; Y - A; Z - C. **D.** X - C; Y - A; Z - B.
E. Some other matching arrangement.

	Land Forms	*Agencies*
69. (1.10)	X. anticline	A. diastrophism
	Y. alluvial fan	B. glaciers
	Z. moraine	C. streams
70. (1.10)	X. cirque	A. igneous intrusions
	Y. dike	B. mountain glaciers
	Z. peneplain	C. streams

71. (1.10)

X. basalt
Y. limestone
Z. marble

A. metamorphic
B. sedimentary
C. igneous

72. (1.10)

X. quartz
Y. calcite
Z. mica

A. soft mineral which splits in thin sheets
B. effervesces with HCl
C. hardness 7, glassy, shows no cleavage

73. (1.10)

X. rock salt
Y. mica
Z. silica

A. silicate
B. halide
C. oxide

74 (1.10)

X. earthy
Y. pegmatitic
Z. cubic

A. cleavage
B. fracture
C. texture

75. (1.10) In an anticline the rocks

A. slope downward toward the center of the structure.
B. slope downward away from the center of the structure.
C. are horizontal.
D. slope downward in one direction only.
E. are usually igneous rocks.

76. (1.10) The dissolving activity of ground water is demonstrated in the Grand Ledge, Michigan, area by

A. the presence of erratics in the glacial drift.
B. the joint system in the massive sandstone.
C. deposits of calcareous tufa.
D. the talus heaps at the foot of the cliffs.
E. the high position of the water table along the river.

77. (1.10) Evidence of the youthful stage of the Grand River at Grand Ledge is most indicated by

A. broad flood plains. **B.** a meandering course.
C. steep rock walls. **D.** a steep gradient.
E. a high velocity.

78. (1.10) In the study of the massive sandstone in the Grand Ledge area, ground water moves downward until it reaches the water table marked by

A. joint planes. **B.** concretions. **C.** shale.
D. calcite. **E.** quartz sand.

79. (1.10) At Grand Ledge, the source of the erratics in the glacial drift is

A. north of Lake Huron. **B.** the Rocky Mountains.
C. the Appalachians. **D.** west of Hudson Bay.
E. the Ozarks.

80. (1.10) A peneplain is formed by the action of

A. glaciation. **B.** ground water.
C. running water. **D.** weathering. **E.** the wind.

Items 81 - 86 involve deposited sediments. For each item select from the key the correct classification.

KEY

A. Fluvial. **B.** Glacial. **C.** Glacial-fluvial.
D. Wind. **E.** None of these.

81. (1.10) Till plains.

82. (1.10) Varved-sediments.

83. (1.10) Outwash plains.

84. (1.10) Loess.

85. (1.10) Alluvial fans.

86. (1.10) Drumlins.

87. (1.10) The unconformity in the rocks of the quarry at Grand Ledge was caused by

A. erosion interval and sedimentation.
B. the Grand River and tributaries.
C. continental glacial action.
D. folding and faulting. **E.** vulcanism

88. (1.10) The largest geologic feature in the following list is the

A. geosyncline. **B.** laccolith. **C.** anticline.
D. syncline. **E.** secondary fold.

89. (1.10) Strata distinctly arched so as to approximate the shape of a rainbow form a structure identified as a

A. simple syncline. **B.** simple anticline.
C. geosyncline. **D.** geanticline.
E. symmetrical recumbent fold.

90. (1.10) Caverns and subsurface water systems are characteristic of regions which are underlain at shallow depth by

A. limestone. **B.** shale. **C.** sandstone.
D. coal. **E.** marble.

Items 91 and 92 deleted.

Items 93 - 96 refer to various geologic features of the earth. For each item select from the key the *origin* for each of the pairs given.

KEY

A. Deposition. **B.** Diastrophism. **C.** Erosion.
D. Igneous extrusion. **E.** Igneous intrusion.

93. (1.10) Deltas and sand dunes.

94. (1.10) Anticlines and faults.

95. (1.10) Vesicular basalt and obsidian.

96. (1.10) Moraines and flood plains.

97. (1.10) The Grand River at Grand Ledge was formed

A. from the action of retreating marine waters.
B. when the Appalachian mountains were formed.
C. in its present trough by the gouging action of ice.
D. over a glacial surface and fed from glacial melt waters.
E. largely by chemical weathering processes.

98. (1.10) The materials that compose the earth, the origin of mountains and other topographical features, and how and when the earth originated are problems discussed in

A. physiology. **B.** psychology. **C.** botany.
D. geology. **E.** anatomy.

99. (1.10) Coral reefs and islands are

A. rocks piled up by the sea. **B.** volcanic islands.
C. the last traces of sunken continents.
D. fossilized remains of minute animals.

100. The North American region which has changed the least during the past four geological eras is the region which includes the
(1.10)

A. Grand Canyon. **B.** Appalachian Mountains.
C. Cascade Mountains. **D.** Canadian Shield.
E. central lowland.

101. The entrenched meanders and rejuvenated streams of the present Appalachian Mountains are evidence of
(1.24)

A. the formation of a new geosyncline.
B. the occurrence of crustal shortening resulting in re-elevation.
C. glacial action. **D.** slipping and faulting.
E. the presence of alternate layers of hard and soft rocks.

102. A mineral differs from a rock in that a mineral is always
(1.23)

A. an ore. **B.** an element or a chemical compound.
C. a metallic oxide. **D.** of economic value.
E. of igneous origin.

103. Sedimentary deposits of clay or mud after being subjected to pressure change to layers of
(1.10)

A. conglomerate. **B.** sandstone. **C.** shale
D. limestone. **E.** chert.

104. Further pressure exerted on the rock referred to in the preceding exercise may ultimately change it to
(1.10)

A. marl. **B.** marble. **C.** quartzite.
D. slate. **E.** flint.

105. In a region in which are found caves, sinkholes, and natural bridges, one would also be most likely to find
(2.30)

A. dikes. **B.** petrified tree trunks.
C. laccoliths and batholiths.
D. stalactites and stalagmites. **E.** talus slopes.

106. The action of a geyser best illustrates which of the following principles?
(1.30)

A. At high altitudes water boils at temperatures lower than 212°F or 100°C.
B. Ground water produces fissures.
C. Water containing dissolved salts boils at higher temperatures than pure water.
D. The temperature at which water boils varies with the pressure.
E. The heat of vaporization of water is 540 calories per gram.

107. The chief factor in the production of black or humus soils is the action of
(1.10)

A. running water. **B.** differential erosion.
C. bacteria on organic material.
D. cultivation and grazing. **E.** ground water.

108. A cliff of relatively porous rocks stands in a region where there are considerable variations in temperature. Here one would expect to find
(2.30)

A. loess. **B.** talus. **C.** alluvial deposits.
D. faults. **E.** eskers.

109. Which one of the following has the least in common with the rest of the group?
(1.10)

A. Striae. **B.** Moraine. **C.** Esker.
D. Till plain. **E.** Outwash plain.

110. An unsorted type of deposit would be most likely to occur in which of the following features?
(1.10)

A. Esker. **B.** Sand dune. **C.** Moraine.
D. Delta. **E.** Stream bed.

111. The land surface as found in a mature region
(1.10)

A. is mostly covered with steep sided canyons.
B. is mostly covered with original upland.
C. shows such depositational features as moraines.
D. is poorly drained by a sluggish system of rivers.
E. is thoroughly drained by a complex system of tributary rivers.

112. The water table generally
(1.10)

A. is found only in regions of heavy rainfall.
B. follows the contour of the land.
C. falls during rainfall because of increased weight.
D. is found in regions covered mostly with the sloping sides of hills.
E. has all of the above as its characteristics.

113. A typical youthful river valley shows which of the following characteristics?
(1.24)

A. Few short tributaries.
B. Carries fairly large rocks.
C. Flood plain begins to form.
D. All three of the above.
E. Only the *first two* characteristics and not the third.

114. Which geological feature is out of place in the following list?
(1.10)

A. Concretion. **B.** Petrified wood.
C. Mineral vein. **D.** Geode. **E.** Cavern.

115. A water fall
(1.10)

A. is due to differential erosion.
B. is a transitory feature.
C. can be produced by glacial erosion.
D. may have all of the above three characteristics.
E. is characterized *only* by the *first two* above.

116. The deposition of a stream increases as the
(1.10)

A. velocity increases. **B.** velocity decreases.
C. particle size decreases.
D. volume of water increases.
E. slope of the bed increases.

117. The Mississippi Delta was formed
(1.10)

A. as the flood plains pushed their way out into the Gulf of Mexico.
B. by stream deposition caused chiefly by an increase in velocity due to an increase in the amount of water near the gulf.
C. by stream deposition due to longshore currents.
D. by stream deposition due to a decrease in the velocity as the stream waters enter the quiet waters of the gulf.
E. by deposition caused by an increase in friction as the stream floods its banks.

118. Caverns and underground tunnels occur in limestone
(1.10) strata when ground water

A. contains dissolved minerals.
B. has been heated by contact with hot masses of rock.
C. contains dissolved carbon dioxide.
D. attacks a recent igneous intrusion.
E. emerges to form a spring.

119. In the subway, one sometimes sees icicle-like pendants
(1.10) hanging from the roof where water has worked its way through the masonry and dissolved in mortar. These are similar to

A. stalactites. **B.** dikes. **C.** geodes.
D. concretions. **E.** agate.

120. A geologist notes in a certain region the following geo-
(2.30) logical features: A sinkhole leading to extensive underground caverns. On further investigation he notices icicle-like pendants projecting from the ceiling and floors of these caverns. He therefore concludes that the rock strata underlying the region are

A. sandstone. **B.** limestone. **C.** slate.
D. basalt. **E.** quartz.

121. The formations mentioned in item 120 are most likely
(1.10) due to the action of

A. glaciers. **B.** volcanoes. **C.** ground water.
D. running water. **E.** shore agents.

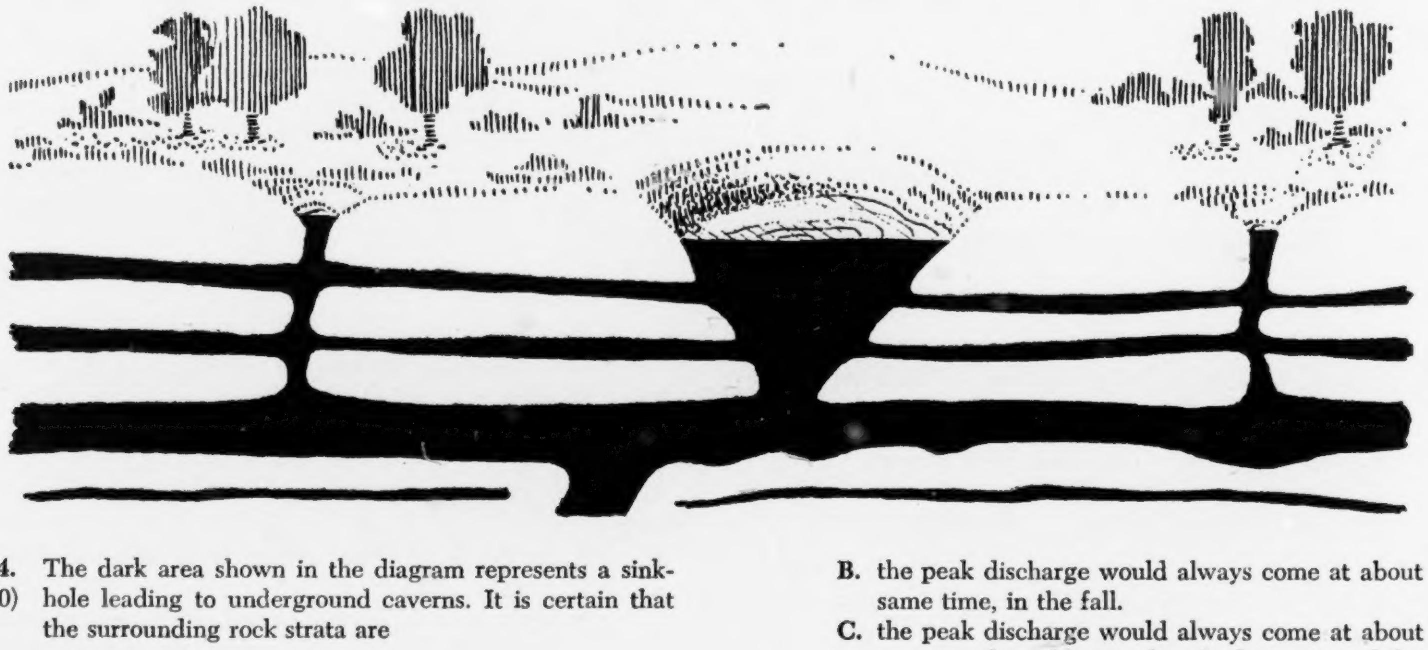
122. The projections from the floors and ceilings are
(1.10)

A. geodes. **B.** concretions. **C.** cirques.
D. eskers. **E.** stalactites and stalagmites.

123. The structures mentioned in item 122 are made up
(1.10) principally of

A. basalt. **B.** marble. **C.** quartz.
D. calcium carbonate. **E.** silica.

For items 124 and 125 use the following diagram.



124. The dark area shown in the diagram represents a sink-
(1.10) hole leading to underground caverns. It is certain that the surrounding rock strata are

A. sandstone. **B.** limestone. **C.** slate.
D. rhyolite. **E.** quartz.

125. Such a sinkhole and the caverns would not form unless
(1.10) the ground water

A. is at a high temperature.
B. contains silica. **C.** is flowing rapidly.
D. contains carbon dioxide in solution.
E. alternately freezes and thaws.

126. An essential condition for the successful drilling of an
(1.10) artesian well is the existence of a

A. meandering stream.
B. sloping layer of pervious rock between layers of impervious rock.
C. spring at the lowest level in a valley.
D. pervious rock layer in the form of an anticline.

127. Niagara Falls will eventually disappear. This is true,
(1.10) because

A. the Great Lakes will tip westward.
B. the Great Lakes will tip southward.
C. the limestone blocks will build up to the falls.
D. the remaining limestone tilts down toward Lake Erie.
E. there is little limestone left above the falls.

128. Which of the following aspects of Chicago and the
(1.10) region around Chicago have been caused directly or indirectly by glaciation?

A. The Palos Hills. **B.** Lake Michigan.
C. The level plain on which Chicago is built.
D. The Chicago River. **E.** All of the above.

129. The existence of alternate strata of varying hardness and
(1.10) their later subjection to glacial gouging were important factors in the formation of the

A. Appalachian Mountains. **B.** Canadian shield.
C. Great Lakes. **D.** Niagara limestone.

130. Graphs showing volume discharge during flood condi-
(1.10) tions of different years on our principal New England rivers would show a striking similarity in that

A. the peak discharge would always be practically the same.
B. the peak discharge would always come at about the same time, in the fall.
C. the peak discharge would always come at about the same number of hours after the beginning of the rise of the flood waters.
D. the highest discharge would always be in the spring of the year.
E. the time involved in the rise of the water to a condition of peak discharge is always shorter than the time involved for the water to subside from peak flood condition to normal flow.

131. (2.20) My answer to question 130 is correct because of the fact that

A. New England is so relatively small that precipitation would be about equal in all parts of the area.
B. the heaviest precipitation usually comes in the fall.
C. natural storage facilities are present on each of the principal rivers and it takes more time for the water to drain off the flood plains than it does for it to accumulate on the flood plains.
D. snow melting in spring plus rains would always cause greater floods to occur in the spring than at other times.
E. our principal rivers are so nearly alike in their characteristics that they would tend to show the same peak which would come at about the same number of hours after the beginning of the rise of the flood waters.

132. (1.10) Most of the water derived from dug wells is from which of the following sources?

A. Magmatic water. **B.** Meteoric water.
C. Connate water. **D.** Vadose water.
E. None of these.

The statements below represent the effects of certain causes. After the *first* of the two numbers following the statement, blacken the *one* lettered space which designates the cause. After the second number, blacken the *one* lettered space which designates the rock, mineral, or geological formation participating in the cause and effect relationship.

Statement: An amphitheater-like depression is close to the top of a certain high mountain.

133. (1.10) **A.** Wind. **B.** Running water. **C.** Ice.
D. Oxidation, hydration, and carbonation.
E. Atmosphere.

134. (1.10) **A.** Cirque. **B.** Canyon. **C.** Sinkhole.
D. Crevasse. **E.** Pothole.

Statement: A certain rock contains parallel scratches on its face.

135. (1.10) **A.** Wind. **B.** Running water. **C.** Ice.
D. Wind and ice. **E.** Waves.

136. (1.10) **A.** Geode. **B.** Striae. **C.** Stalactites.
D. Metamorphosed rock. **E.** Concretions.

Statement: A long, winding, narrow ridge of sand and gravel contains granite pebbles deposited on a bedrock of limestone.

137. (1.10) **A.** Ice and water. **B.** Wind. **C.** Waves.
D. Ground water. **E.** Diastrophism.

138. (1.10) **A.** Alluvial fan. **B.** Esker.
C. Entrenched meanders. **D.** Divide. **E.** Delta.

Statement: A certain rock changes to brilliant, snow-white marble.

139. (1.10) **A.** Intrusion of molten igneous rock. **B.** Faulting.
C. Action of circulating ground water.
D. Rapid cooling.
E. Oxidation, hydration, and carbonation.

140. (1.10) **A.** Granite. **B.** Basalt. **C.** Shale.
D. Quartzite. **E.** Limestone.

Statement: A certain rock is hollow on the inside and partly filled with crystals of quartz.

141. (1.10) **A.** Ground water. **B.** Carbonated water.
C. Hot water. **D.** Steam expansion.
E. Replacement.

142. (1.10) **A.** Schist. **B.** Stalagmite. **C.** Travertine.
D. Geode. **E.** Cirque.

143. (1.10) In dealing with groundwater we often use the terms porosity, permeability, impermeability. Which of the following is most important in producing impermeability?

A. The amount of pore space in the material.
B. The large size of the particles in the material.
C. The attraction the particles have for the water.
D. The total thickness of the mantle.
E. The kind of topography, whether flat or gently rolling.

144. (1.10) With one exception the following activities of man tend to lower the water table. Which one is the exception?

A. Overgrazing. **B.** Deforestation. **C.** Pumping.
D. Use of commercial fertilizers rather than animal manure.
E. None of the above.

145. (1.10) Which one of the following statements concerning artesian water is *incorrect?*

A. The thicker the aquifer and the greater its areal extent, the larger the storage of water.
B. The shorter the distance from the intake to the well site, the greater the loss of pressure due to friction and capillarity.
C. The more fractured the roof over the aquifer, the weaker the pressure and flow because of leakage.
D. The higher the intake in relation to surface elevation at the well site, the greater the pressure.
E. The more permeable the aquifer, the faster the flow of water through it.

146. (1.10) In an area of moderately folded rock structure which has been developed to the stage of maturity under humid conditions, the pattern of drainage is generally

A. consequent. **B.** trellis. **C.** obsequent.
D. dendritic. **E.** none of the above.

147. (1.10) In regions like the Appalachians with folded rocks and with transverse streams, which one of the following terms would be applicable to those transverse streams?

A. Antecedent. **B.** Subsequent. **C.** Braided.
D. Obsequent. **E.** None of these.

148. (1.10) Which one of the following statements is *incorrect?*

A. Vadose water causes the solution of materials at the earth's surface.
B. In northern New England artesian wells there is probably no fluctuation whatever in the level of the water in the wells since such wells are drilled in consolidated rocks.
C. Underground water in homogeneous materials moves downward and outward from under the hills towards the lower lands.
D. In practically all areas the water table fluctuates with the rainfall.
E. A well that is dug deep enough to tap a perched water table may yield enough water for an individual's needs and then, under certain conditions, may fail in supply.

149. (1.10) One great difference between eskers and drumlins is:

A. Drumlins are longer than eskers.
B. Eskers are higher than drumlins.
C. Drumlins are found mainly in shallow sea water while eskers are mainly on stream divides.
D. Drumlins are composed of unstratified till while eskers are composed of stratified sands and gravels.
E. Eskers occur only in the ground moraine while drumlins occur north of the end moraine.

150. (1.10) Assume you were given the task of finding out something about the length of time that the Connecticut Valley at Hanover was occupied by lake waters. Which one of the following would afford the most data?

A. The valley of Blood Brook.
B. The valley of Mink Brook.
C. The valley of Girl Brook.
D. The Bema. **E.** Balch Hill.

151. (1.10) In an area of low relief, although no ice is now present, it is easy to tell that glaciation once occurred because of

A. the prevalence of arretes.
B. the great number of cirques.
C. the many hanging valleys.
D. the prevalence of many medial moraines.
E. the prevalence of ground moraine.

152. (1.10) The direction of motion of the ice sheet is best indicated by

A. kettle holes. **B.** kame terraces.
C. sheep rocks *(roches moutonnees).*
D. varved clays. **E.** eskers.

153. (1.10) Assume that you were travelling and saw certain areas, particularly the Grand Canyon of the Colorado. A companion asks you to explain the origin of the Canyon. Which one of the following would be primarily involved in your answer?

A. Mineralogy. **B.** Economic geology.
C. Geomorphology. **D.** Petrology.
E. Paleontology.

154. (1.10) All but one of the following are due to a combination of structure and stream erosion. Which one is the exception?

A. Hogbacks. **B.** Mesas. **C.** Cuestas.
D. Waterfalls. **E.** Floodplains.

155. (1.10) Which one of the following is not usually found in arid regions?

A. Sand dunes. **B.** Ventifacts. **C.** Pediments.
D. Playas. **E.** Deep residual mantle.

156. (1.10) Which one of the following statements is correct?

A. A cuesta can be formed only by the action of stream erosion on tilted layers of rock of different resistance.
B. Pediments are the piles of debris left at the base of mountains where streams deposit their load of debris upon the plains.
C. Barchans usually have a small oasis with palm trees growing between the tips of the dunes.
D. Mesas are usually very small in size, say about 200 feet in diameter.
E. None of the above.

157. (1.10) From an ordinary topographic map which one of the following could *not* be determined?

A. The elevation of a given point within the limit of the contour interval.
B. The slope of the land between any two points.
C. The direction of the flow of streams.
D. The gradient of any stream between two given points.
E. An accurate idea of the thickness of the mantle.

158. (1.10) Only one of the following statements is false. Which one?

A. The geology of the earth has played an important role in separating different groups of people throughout historical times.
B. The geology of the earth has had an important influence on the cultural development of man since the very beginning of human history.
C. The study of geology has many practical applications in the fields of agriculture, mining, the construction of dams and bridges, and in hydrology.
D. The important applications of geology concern man's search for precious and useful metals, petroleum, and other fuels.
E. The geology of the earth has always been considered by diplomats in making treaties between nations.

159. (1.10) Which one of the following statements is correct?

A. The continental shelves are not more than 5 miles wide anywhere along the Atlantic Coast between Newfoundland and Massachusetts.
B. Submarine valleys extending from the shore line outward across the continental shelves are known as "trenches."
C. The great Oceanic currents are almost as effective eroding agents as are the currents made by wave action.
D. The shape of sea cliffs depends in large part upon the kind of material of which the cliff is composed and the structure of that material.
E. None of the above.

160. (1.10) If you were a contractor living in the general Hanover area and wanted to secure considerable quantities of gravel for construction purposes, which of the following, if you could find them near at hand, would probably give you the largest supply?

A. Cuestas. **B.** Ground moraine.
C. Subsidence layer of Lake Hitchcock.
D. Deltas of Lakes Hitchcock and Upham.
E. The beaches of Lakes Hitchcock and Upham.

161. (1.10) Three, and only three, of the following regions are relatively stable shield areas of ancient rocks.

1. Western Australia. 2. Yunnan Plateau.
3. Atlas Mountains. 4. Labrador. 5. Sweden.

The shield areas are

A. 1, 2, and 3. **B.** 1, 4, and 5. **C.** 2, 3, and 4.
D. 3, 4, and 5. **E.** 1, 2, and 4.

162. (1.10) Three, and only three, of the following are massifs, formed by faulting of old highlands.

1. Tibetan Plateau. 2. Yunnan Plateau.
3. Rhodope Mountains. 4. Appalachian Mountains.
5. Sierra Nevada Mountains of California.

5

The massifs are

A. 1, 2, and 3. **B.** 3, 4, and 5. **C.** 2, 3, and 4.
D. 1, 3, and 5. **E.** 2, 3, and 5.

163. (1.10) Which two of the following highlands most closely parallel each other as regards their developmental history?

1. Appalachian Mountains. 2. Scottish Highlands.
3. Rocky Mountains. 4. Ural Mountains.
5. Vosges Mountains.

The two highlands with most similar history are

A. 1 and 4. **B.** 1 and 5. **C.** 4 and 5.
D. 2 and 3. **E.** 3 and 4.

164. (1.10) Three, and only three, of the following plateaus are included in the strip of recently-formed highlands.

1. Mongolian Plateau. 2. Altiplano de Peru.
3. Anatolian Plateau. 4. Tibetan Plateau.
5. Columbia Plateau.

The newly-formed plateaus are

A. 1, 2, and 3. **B.** 3, 4, and 5. **C.** 2, 4, and 5.
D. 1, 3, and 5. **E.** 2, 3, and 5.

165. (1.10) Three, and only three, of the following mountains are included in the strip of recently-formed highlands.

1. Ural Mountains. 2. Pindus Mountains.
3. Sulaiman Range. 4. Brooks Range.
5. Appalachian Mountains.

The recently-formed mountains are

A. 1, 2, and 3. **B.** 2, 3, and 4. **C.** 3, 4, and 5.
D. 2, 3, and 5. **E.** 1, 3, and 5.

For items 166 - 172 mark:

A. if the item represents a true sequence.
B. if the item does not represent a true sequence because an event not pertinent to the major sequence is listed.
C. if the item does not represent a true sequence because the order of the events is incorrect even though all the essential events are listed.

166. (1.20) Formation of coral; elevation of sea floor; sinking and inundation; deposition of mud from river drainage; another elevation above sea-level; percolation of ground water containing carbon dioxide; formation of caves.

167. (1.20) Glaciation; formation of hanging valley; drainage of rain water; cascade.

168. (1.20) Deposition of mud; consolidation of sediment; formation of granite; formation of shale; metamorphic change resulting in slate.

169. (1.20) Intrusion of magma; cooling; formation of sandstone; formation of coarse-grained igneous rock.

170. (1.20) Old, meandering river; very young stream; youthful river; peneplain; mature river.

171. (1.20) Submergence of a continent; deposition of river-drained mud and clay; elevation of sea-floor; formation of fjords.

172. (1.20) Extrusion of lava; cooling with formation of fine-grained igneous rocks; formation of a cinder cone; formation of a lava cone.

173. (1.20) In order to determine the method by which certain mountains were formed, it is most useful to

A. observe the velocity of the river waters.
B. measure the height of the mountains above sea level.
C. determine the composition of the rock formations.
D. study the types and shapes of the rock formations.
E. determine the isostacy of the region.

174. (1.22) Below are listed various stages of the nitrogen cycle. The stages are not listed, however, in the order in which they occur in nature. You are to arrange them in that order.

1. Conversion of plant organic nitrogen compounds by herbivorous animals into nitrogen compounds present in their tissues.
2. Absorption of nitrogen compounds, present in the topsoil, through the roots of the plants.
3. Introduction of uncombined nitrogen into the topsoil, either by rainfall or by aeration.
4. Return to the atmosphere of nitrogen contained in tissues of putrefying dead animals.
5. Fixation by micro-organisms of the uncombined nitrogen in the soil into nitrogen compounds.
6. Utilization by plants of the nitrogen compounds absorbed through the roots.

The correct order is

A. 5 2 4 1 3 6. **B.** 3 5 2 6 1 4. **C.** 6 1 4 2 5 3.
D. 3 5 2 4 1 6. **E.** 5 3 2 6 1 4.

175. (1.23) Outwash plains are deposits classified as

A. wind. **B.** fluvial. **C.** glacial.
D. glacial-fluvial. **E.** lacustrine.

176. (1.24) Four of the following refer to the same stage in the geologic development of a region. Which one does not?

A. The uplands consist of broad areas.
B. Major streams meander.
C. Flood plains are well developed.
D. The land surface is thoroughly dissected with a maximum of slope land.
E. Drainage is well established.

177. (1.24) Which one of these is not characteristic of a youthful stage of stream development?

A. The land surface is thoroughly dissected and there is a maximum amount of slope land.
B. Down-cutting is dominant because the streams are not fully loaded.
C. The valleys are V-shaped with bottoms only as wide as the channels.
D. The streams have high gradients and relatively straight courses.
E. Rapids and falls are relatively common.

178. (1.24) The banks of a meandering stream are V-shaped. This is evidence that this region has been subjected to

A. glaciation.
B. crustal movements increasing the gradient of the stream.
C. forces which increase the lateral erosion of the stream.
D. extensive alluvial deposition.
E. a lowering of the level of the land in the region.

179. The entrenched meanders and rejuvenated streams of
(1.24) the present Appalachian Mountains are evidence of

A. the formation of a new geosyncline.
B. the occurrence of crustal shortening resulting in re-elevation.
C. glacial action. **D.** slipping and faulting.
E. the presence of alternate layers of hard and soft rocks.

180. The presence of estuaries, drowned valleys, and penin-
(1.24) sulas is characteristic of

A. submergent shores.
B. continental shelves along a coast line.
C. submarine volcanic coast lines.
D. neutral type shore lines. **E.** emergent shores.

181. The Grand River valley at Grand Ledge shows some
(1.24) characteristics of youth. Which one of the following features would not be such a characteristic?

A. Steep rock walls. **B.** Islands in the stream.
C. Bend in the course due to a tributary.
D. Channel as wide as the valley.
E. Incipient gullies.

182. Four of these refer to the same stage in the develop-
(1.24) ment of streams. Which one does not?

A. The interfluves are broad areas.
B. Major streams meander.
C. Drainage is well established.
D. Flood plains are well developed.
E. The land surface is thoroughly dissected with a maximum of slope land.

Item 183 deleted.

184. The *difference* between a valley which was formed by
(1.24) a glacier and one which was formed by running water.

A. The former is always V-shaped while the latter is always U-shaped.
B. Parallel scratches often occur in the rock of the former.
C. Hanging valleys are often tributaries of the former.
D. All of the above.
E. Both B and C of the above.

185. Which of the following characteristics would enable you
(1.24) to recognize the deposits of a continental ice sheet?

A. Sediments unsorted with respect to size.
B. Sediments containing many different types of rock, spread over a large area.
C. Sediments having an irregular, hilly, undrained topography.
D. All of the above. **E.** None of the above.

186. The existence of a flood-plain along a stream
(2.30)

A. indicates that the stream must be more than 15 million years old.
B. is made only when the stream has cut down to very hard rock.
C. indicates that the stream's rate of downcutting has decreased to almost, but not quite, zero.
D. shows that the rate of weathering has increased markedly, and rather rapidly.
E. suggests that the stream is very old, and will shortly die for lack of water.

187. Why is Niagara Falls thought to be only a temporary
(1.24) feature of the landscape?

A. Lake Erie, which supplies water to the Niagara River, is slowly drying up.
B. No waterfall can be more than 25,000 years old, and Niagara Falls is already 10,000 years old.
C. Diastrophic movements of Lake Ontario, into which Niagara empties, will raise the lake level so that it will eventually be higher than the Falls.
D. The limestone over which the river flows, overlies softer rocks and slopes downward toward the west.
E. Water flows faster on steeper slopes, so the Falls is being eroded more rapidly than other portions of the Niagara River channel.

188. The *difference* between rhyolite and granite.
(1.24)

A. Acidity. **B.** Alkalinity.
C. Chemical composition. **D.** Size of crystals.
E. Degree of metamorphosis.

189. The *difference* between basaltic and rhyolite lavas.
(1.24)

A. The former are predominantly of ferromagnesian minerals while the latter contain an excess of silica.
B. The former are porous as exemplified by pumice while the latter are scoriaceous.
C. The former are igneous while the latter are not.
D. The former may form volcanic glass while the latter will not.
E. The latter are more fluid than the former.

190. The *difference* between a moraine and an esker.
(1.24)

A. The former is formed by glacial action while the latter is not.
B. The former is formed along the sides or ends of glaciers while the latter is formed beneath a glacier.
C. The former is formed at the end of a glacier, the latter at the head of a glacial valley.
D. The latter is the outwash plains which protrude from the former.
E. The former contains rocks while the latter does not.

191. The *difference* between a concretion and a geode.
(1.24)

A. The latter is formed by replacement while the former is not.
B. The former is made of calcite while the latter is made of silica.
C. The former represents a deposit on a nucleus of some sort while the latter represents a deposit in some opening and may be hollow.
D. The former is a result of the action of ground water while the latter is a result of the action of a running water.
E. The latter is more likely to contain a fossil than the former.

192. The *difference* between a valley which was formed by
(1.24) a glacier and one which was formed by running water.

A. The former is always V-shaped while the latter is always U-shaped.
B. The former represents an example of the work of diastrophism while the latter does not.
C. Hanging valleys are often tributaries to the latter.
D. The former is more likely to be U-shaped.

193. The *difference* between cirques and striae.
(1.24)

A. Striae but not cirques may be taken as evidence of the presence of a glacier in the past.

B. Cirques are examples of glacio-fluvial deposits, while striae are streaks in rocks due to varying crystalline structure.

C. Cirques are amphitheater-like depressions cut by glacial ice at the heads of valleys while striae are glacial scratches on rocks.

D. Cirques are hanging valleys while striae are types of eskers.

E. A cirque is a crevasse while a striae is a crack.

194. One *difference* between an old and winding stream and one that has been rejuvenated.
(1.24)

A. The former is characterized by meanders while the latter is not.

B. The former stream flows faster than the latter.

C. The former has tributaries while the latter does not.

D. The latter may have entrenched meanders.

E. The latter has none of the characteristics of a youthful stream.

195. The *difference* between diastrophism and gradation.
(1.24)

A. Diastrophism tends to build up mountain ranges, while gradation tends to level continents.

B. Gradation includes both aggradation and degradation.

C. Diastrophism is related to aggradation, but is in no way related to degradation.

D. Diastrophism always involves movements of molten magma, while gradation affects only sedimentary or metamorphic rock.

E. Gradation involves extensive changes in the earth's crust, while diastrophism is concerned with minor disturbances.

196. During the disappearance of the ice sheet from the Hanover area, the Connecticut Valley was occupied by a lake, two different levels of which are marked by
(1.24)

A. weathered till above fresh till.

B. thin ground moraine on the higher lands.

C. considerable thicknesses of varved clays underlying the campus.

D. the old meander scars of Girl Brook.

E. none of these.

197. Which one of the following statements concerning frost action is correct?
(1.24)

A. All frozen ground in the Hanover region is a remnant of the frozen ground related to the Pleistocene ice sheet which formerly occupied the region.

B. The depth of frost in the ground in the Hanover area varies depending on the thickness of the ground moraine in different places in the area.

C. In the Arctic regions of Permafrost, highway construction is the only activity in which frozen ground is important.

D. In the Hanover region frozen ground is of great importance in relation to water supply as derived from dug wells.

E. The depth of frozen ground in the Hanover region depends upon the number of times the soil temperature fluctuates about the freezing point and the amount of water in the soil.

198. Drilling artesian wells in northern New England is a gamble because of conditions listed below. Which one of these conditions is *not applicable?*
(1.24)

A. The aquifer varies in depth from place to place and, since it does not outcrop in many places, it is rarely possible to predict at what depth the aquifer will be encountered.

B. The rocks of northern New England are primarily granites and metamorphic rocks and as such their pore spaces are usually very small and do not readily permit the passage of water through them.

C. Our topography, except for the larger valley areas is so rough and the places where water can get into fractures are so hidden that we cannot tell just how deep we must drill to strike a water-bearing fracture.

D. The fractures do not persist with depth but become fewer in number and farther apart with increasing depth.

E. The fractures do not persist horizontally so that while you might drill to a depth of 100 feet and get a plentiful supply of water, your neighbor at 1000 feet distance away, and at the same elevation might get none at that depth.

199. One of the conditions listed below favors the development of strong shore currents. Which one?
(1.24)

A. Winds which blow in an off-shore direction.

B. Winds which blow nearly straight on-shore.

C. Winds which blow long and steadily and diagonally towards the shore.

D. Winds which blow first from one direction and then from another direction.

E. A regular shore line.

200. Which one of the following would give the more correct view as to the rate at which the ice front melted northward in the Connecticut Valley?
(1.24)

A. The thickness of till in the valley.

B. Matching of graphs of varved clay sections at various places along the valley.

C. The number of feet of thickness of varved clays at given places along the valley.

D. The depth of the stream valley itself.

E. The height of the abandoned meander scars of Girl Brook above the present level of the Connecticut River.

201. A region which has been reduced to a peneplain condition under humid climate would have all but one of the following conditions. Which one is the exception?
(1.24)

A. Very low slopes.

B. Wide flood plains.

C. Possibly a few monadnocks.

D. Thin soils mostly of glacial origin.

E. Poor drainage at the heads of tributary streams which are shrinking in size.

202. (1.24) Certain features and conditions present in Norway and Sweden cannot be explained by a lowering of sea level because

A. they are sometimes relatively far from the shore line.
B. they are too extensive and cover too much area.
C. they do not occur on a horizontal plane.
D. they are covered with scanty vegetation.
E. there has not been enough time since they were formed or were in existence for sea level to have been lowered.

203. (1.24) The best evidence for the idea that the Connecticut Valley at Hanover was occupied by ice before the existence of Lakes Hitchock and Upham would be

A. glacially-scoured rock ledge near the Old Pine stump in College Park.
B. small delta in Connecticut River near Ledyard Bridge.
C. till resting on top of varved clays.
D. glacially striated quartz ledges.
E. till underneath varved clays and above striated bedrock.

204. (1.24) The hinge line along the Atlantic Coast of New England *cannot* be located because

A. its position has become obscure due to glacial debris covering it.
B. the ice in a later forward movement eroded it.
C. since no tilting or warping occurred in this area there could be no hinge line.
D. it has been submerged by rise in sea level due to addition of water from the melting ice.
E. none of the above.

205. (1.24) On a topographic map it is usually possible to determine the difference between topography due primarily to wind action and that formed by development of caverns because

A. the hollows resulting from wind action would always be circular due to the eddying action of the wind, while hollows due to cavern development would be irregular in shape.
B. the hollows resulting from wind action would be apt to be deeper than those resulting from cavern development.
C. the hollows resulting from cavern development generally occur in any kind of rocks while those due to wind action would only occur in types of rocks which are softer and more easily eroded.
D. the hollows due to cavern development would be apt to be irregular in shape and arranged along lines, while those due to wind action would have no particular arrangement.
E. none of the above conditions would show the difference.

206. (1.24) The following are characteristic features of certain stages in the development of river systems.

1. Sluggish current. **2.** Wide, flat-floored valleys.
3. Narrow, V-shaped valleys. **4.** Ox-bow lakes.
5. Waterfalls and rapids.
6. Relatively straight river bed.

Which one of the following choices indicates only those features which are typical of the old-age stage of development of river systems?

A. 1, 2, 6. **B.** 3, 5, 6. **C.** 2, 4, 6.
D. 3, 4, 5. **E.** 1, 2, 4.

207. (1.25) We can infer that the crust of the earth is thin, about 25 miles thick, and is composed of differing materials arranged in stratified layers from

A. study of the structure of sedimentary rocks.
B. study of earthquake waves.
C. study of igneous intrusions.
D. study of barrier reefs.

208. (1.25) Assume that you were going to try to locate some advantageous parking areas in the village of Hanover and were forced to consider the cost of leveling the areas and filling the hollows (knowing that the surface material is all unconsolidated), which of the following would be of most use to you?

A. The ordinary Hanover quadrangle map.
B. A structure contour map of the Hanover area.
C. A Congressional Land Survey System map of the Hanover area.
D. A road map such as is issued by oil companies.
E. None of these.

209. (2.20) Refer to the problem in item 208 again, and suppose that you could get a map of the Hanover area with a scale 4 times as large as that of the ordinary quadrangle map which has a scale of 1 : 62,500. Which one of the following statements is correct?

A. The scale of the enlarged map would be 1: 125,000.
B. The scale of the enlarged map would be 1: 500,000.
C. The scale of the enlarged map would be 1: 250,000.
D. The scale of the enlarged map would be 1: 31,250.
E. The scale of the enlarged map would be 1: 15,625.

210. (2.20) Refer to the problem in item 209. The enlarged map would be

A. one-half as large as the quadrangle map.
B. one-quarter as large as the quadrangle map.
C. twice as large as the quadrangle map.
D. eight times as large as the quadrangle map.
E. sixteen times as large as the quadrangle map.

211. (1.30) If you were asked to observe a certain stream and determine its relative velocity at flooded peak in contrast with that at normal flow you would make use of which one of the following?

A. The Davis Cycle of Erosion theory.
B. The Chezy formula.
C. The doctrine of Uniformitarianism.
D. Structure contours. **E.** None of the above.

212. (1.30) In a given area geologists have often stated that there are several peneplains at different levels, as shown by accordant ridge tops. Which one of the following statements is correct?

A. The detection of remnants of former peneplains is often based upon profiles drawn from topographic maps and, since the profiles always cut the tops of the ridges, they indicate the remnants of former higher peneplains.

B. Despite earth movements occurring in fairly recent times, erosion takes place so rapidly that there is plenty of time for newer and lower level peneplains to form.

C. The formation of a peneplain with later uplift and rejuvenation would permit formation of a newer and lower level peneplain without destruction of the earlier one.

D. The different levels of accordant ridges presumed by some to be remnants of different peneplains at different levels can often be explained by structural conditions.

E. With increasing length of time the processes slow down and hence the remnants of former higher level peneplains would naturally be preserved while younger ones are formed at lower levels.

213. (2.10) Region X is the valley of a sluggish stream which meanders through a region of rounded hills with a well-developed drainage system. Region X is

A. a mature river valley. **B.** a glaciated valley.
C. a youthful river valley. **D.** a volcanized stream.
E. an anticline.

214. (2.10) A depression originating in a continental block as a great trough and destined to be filled with sediments is descriptive of

A. a fault. **B.** an anticline. **C.** geosyncline.
D. a joint in the lithosphere. **E.** none of the above.

215. (2.10) On a certain mountaintop the barometer height was about 24 inches. Estimate the approximate elevation of the mountaintop above sea level. It is about

A. 10,000 feet. **B.** 12,000 feet. **C.** 8,000 feet.
D. 14,000 feet. **E.** 6,000 feet.

Items 216 - 226.

A surveyor is mapping an area which is characterized by major streams meandering on flood plains no wider than the meander belts of the streams. The divides between the major streams are not flat topped but have been carved into slope land. The tributary streams flowing down them find sufficient gradient to form frequent but low falls and rapids. The tributary valleys are not hanging. The drainage as a whole is by no means sluggish or inadequate.

The soil on the hillsides and the hill tops is the product of the disintegration of the underlying bedrock. There are no rocks or boulders present in the soil which are foreign to the region. In the sides of the road cuts it is apparent that the soil grades gradually into the disintegrating rock below.

He has his transit set near a low cliff. Two-thirds of the way up this cliff is a mass of soft, porous rock clinging to the bedded rock of which the cliff is composed. Water is seeping from the cliff over this soft rock. The rock effervesces when hydrochloric acid is placed upon it. The strata of the cliff are cracked vertically but there is no indication of any movement along these vertical fractures.

His transit is set on a common igneous rock composed of mineral grains of three minerals. The mineral grains may be easily distinguished and examined with the naked eye. One of the three minerals is white or colorless, has a hardness of 7 (cannot be scratched with a knife), conchoidal fractures which streak, a vitreous luster, and is an oxide of silicon. The second is a potassium-aluminum silicate, flesh colored with a hardness of 6. It has two good cleavage planes making an angle of 90 degrees with each other. It is often used in the manufacture of porcelain. The third mineral is black with perfect cleavage in one direction. The mineral flakes off in thick, flexible, elastic sheets along this cleavage plane. It has a hardness of 2.5 to 3.

216. (2.10) The porous rock clinging to the rock wall is

A. calcareous tufa. **B.** talus. **C.** granite gneiss.
D. stalactite. **E.** underclay.

217. (2.10) The first mineral described is

A. orthoclase. **B.** fluorite. **C.** apatite.
D. quartz. **E.** topaz.

218. (2.10) The second mineral described is

A. quartz. **B.** a feldspar. **C.** kaolin.
D. chlorite. **E.** hornblende.

219. (2.10) The third mineral described is

A. muscovite. **B.** quartz. **C.** talc.
D. biotite. **E.** gypsum.

220. (2.10) The igneous rock on which the transit is set is

A. diorite. **B.** rhyolite. **C.** granite.
D. andesite. **E.** gabbro.

221. (2.10) The main streams have characteristics of

A. youth. **B.** maturity. **C.** old age.
D. rejuvenation. **E.** a peneplane.

222. (2.10) The regional characteristics are those of

A. youth. **B.** maturity. **C.** old age.
D. rejuvenation. **E.** a peneplane.

223. (2.10) The tributary streams have characteristics of

A. youth. **B.** maturity. **C.** old age.
D. rejuvenation. **E.** a peneplane.

224. (2.20) From the information given in the passage, the most important type of erosion in this region has most probably been related to

A. ice. **B.** wind. **C.** mass-wasting.
D. ground water. **E.** running water.

225. (2.10) The vertical fractures in the cliff are known as

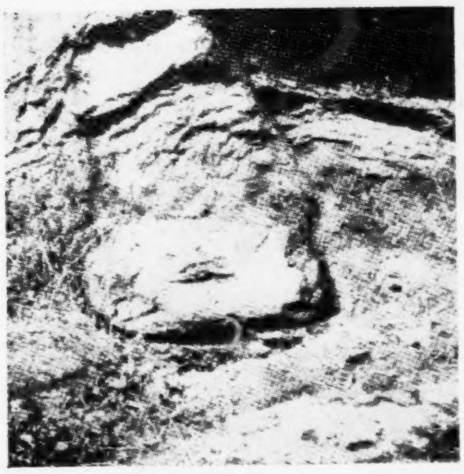
A. faults. **B.** joints. **C.** bedding planes.
D. dikes. **E.** sills.

226. (2.10) The rocks of which the cliff are composed would most probably be

A. igneous. **B.** metamorphic. **C.** sedimentary.
D. granite. **E.** minerals.

Item 227 deleted.

Items 228 - 234 refer to the following photographs.



–A–

–B–

–C–

–D–

–E–

–F–

–G–

It will be recognized that these photographs will not give satisfactory results if reproduced from these pages. They have already suffered in clarity and sharpness of detail because they were reproduced, in turn, from an examination paper. No originals were available. They have been included chiefly to illustrate the kind of pictures which can and should be taken of local phenomena most pertinent to a particular course. For this purpose, ordinary, clear snapshots will suffice.

228. (2.10) Photograph A is most representative of

A. an erratic. B. an unconformity.
C. exfoliation. D. crenulation. E. undercutting.

229. (2.10) Photograph B is most representative of

A. a joint. B. a fault. C. differential weathering.
D. a cleavage plane. E. a syncline.

230. (2.10) Photograph C is most representative of

A. glacial action. B. metamorphism.
C. a talus deposit. D. incompetent bedding.
E. faulting.

231. (2.10) Photograph D is most representative of

A. cross bedding. B. an unconformity. C. foliation.
D. calcareous tufa. E. chemical weathering.

232. (2.10) Photograph E is most representative of

A. an erosional unconformity.
B. differential weathering. C. a youthful valley.
D. slumping. E. undercutting.

233. (1.10) Photograph F shows a coal seam (wide dark band). The material immediately underneath is most likely

A. limestone. B. slate. C. peat.
D. underclay. E. gypsum.

234. (2.20) The most prominent geologic feature in photograph G is

A. a cirque. B. an unconformity.
C. a geosyncline. D. a dike. E. a sink hole.

Items 235 - 238 refer to glacial deposits. From the key select the type of deposit described in each item.

KEY

A. Terminal moraine. B. Esker. C. Till plain.
D. Drumlin. E. Two or more of the above.

235. (2.10) A thickened belt of glacial drift composed of knob-like hills and irregularly distributed kettle-hole-like depressions.

236. (2.10) A gentle rolling plain characterized by long swells with wide, gentle depressions.

237. (2.10) An elliptical hill of glacial drift formed beneath a continental glacier often 50 to 100 feet high.

238. (2.10) Composed of glacial drift which is unsorted.

239. (2.10) In one of the National Parks southwest of Salt Lake City, Utah, the tourist drives through a valley that is unusually scenic and geologically interesting. The cliffs and valley walls have a deep red color. Close examination shows that walls are made up of layers of rock, from which the particles crumble off by simply rubbing them with the thumb. These rocks are probably

A. non-crystalline. B. unaltered metamorphic.
C. sedimentary. D. of igneous origin.

240. (2.10) The particles which fall off by rubbing are almost entirely silica, a compound of silicon and oxygen. The strata can be definitely identified as

A. sandstone. B. granite. C. shale.
D. limestone. E. quartzite.

241. (2.10) Prior to coming down into the valley the highway descends through a man-made tunnel over a mile long which has been cut through the strata. At various places in the tunnel, outcroppings of limestone and shale in addition to the more abundant red-colored strata mentioned above are also found. This suggests an extensive period of

A. erosion. B. glaciation. C. submergence.
D. cave formation. E. volcanism.

242. (1.23) If the answer to item 241 were not tested by consideration of evidence, it would remain

A. an inference. B. an hypothesis.
C. an observation. D. a deduction. E. a principle.

243. (1.10) As one looks about the valley, the characteristic outline appears rather V-shaped. This evidence would point toward gradation being accomplished by

A. ground water. B. running water. C. wind.
D. glaciers. E. volcanism.

244. (2.10) In a Chicago quarry the walls are thick horizontal layers of a pale gray rock which contains many tiny shells of marine animals. It dissolves slowly in water containing carbon dioxide. It is probably

A. sandstone. B. granite. C. basalt.
D. limestone. E. shale.

245. (2.10) For a given stream the Flood Ratio is 500: 1. The approximate relative velocity during flood peak would be

A. $500^{(6)}$. B. $\sqrt{500}$. C. $8^{(3)}$. D. 8. E. $\sqrt{8}$.

246. (2.10) For the same given stream with flood ratio of 500: 1, which of the following would be closer to the carrying power of that stream at flood peak?

A. 260,000. B. 500,000. C. 750,000.
D. 40,000. E. 75,000.

Items 247 - 248. A certain plains region has no well-defined drainage pattern. The ground is flat or slightly rolling, and the surface is dotted with numerous lakes, both large and small. There are numerous funnel-shaped openings through which surface waters drain into underground limestone caverns and subterranean streams.

247. (2.10) The region is probably

A. a mature river valley. B. a karst plain.
C. a plain of recent glacial deposition.
D. a plain recently scoured by glaciation.

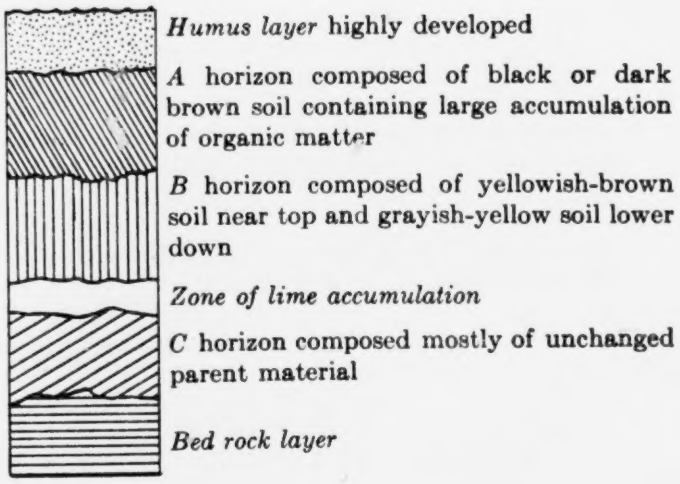
248. (2.10) To which one of the following regions might the above description apply?

A. Columbia Plateau. B. Yunnan Plateau.
C. Carlsbad Cavern region of New Mexico.
D. Yugoslavia. E. Peninsula of Florida.

For items 249 - 250 refer to the profile diagram below.

249. (2.10) What soil-forming process has probably been dominant in the development of this profile?

A. Calcification. B. Laterization. C. Podzolization.
D. Podzolization under tundra conditions.
E. Combined laterization and podzolization.


Humus layer highly developed
A horizon composed of black or dark brown soil containing large accumulation of organic matter
B horizon composed of yellowish-brown soil near top and grayish-yellow soil lower down
Zone of lime accumulation
C horizon composed mostly of unchanged parent material
Bed rock layer

250. (1.10) Under which one of the following vegetation covers might the above soil profile be developed typically?

- **A.** Succulent grass of medium height.
- **B.** Mosses and lichens.
- **C.** Mixed coniferous and deciduous broadleaf forest.
- **D.** Evergreen broadleaf forest.
- **E.** Short bunch-grass and drought-resistant shrubs.

Items 251 - 259 are to be answered by reference to the following article.

A prospector going into the hills follows a U-shaped valley which has an undulating floor with back slopes holding lakes of ponded water. He enters the valley of a tributary by scaling the sides of the main valley around a waterfall and follows the tributary toward its source. This valley is V-shaped with a stream which flows over numerous rapids and small waterfalls. He notices that the cliffs of the valley walls of the tributary are composed of horizontally bedded sedimentary rock. At one spot these strata are distinctly arched approximating the shape of a rainbow. One layer of the formation is of unjointed sandstone from which water is percolating, thus keeping the cliff below the layer moist. He observed symmetrical ripple marks and marine fossils in slabs of sandstone which have fallen to the foot of the cliff. Above the sandstone he finds a coal seam which overlies an underclay. The underclay contains fossils of giant horsetail rushes and club mosses. Above the coal seam are alternate layers of limestone and sandstone.

When he stops to rest, he builds a campfire on a black shaly ledge. The shale turns red from the fire. As he proceeds up the tributary valley, he sees veins with various minerals cutting the sediments. One of the vein minerals, golden to brassy yellow in color, occurred as cubic crystals with metallic luster, hardness 6, uneven fracture and greenish to brownish-black streak. The weathered surface of the vein was streaked with rust.

251. (2.20) The main valley was a product of

- **A.** diastrophism.
- **B.** stream action in a normal fluvial cycle.
- **C.** glacial action.
- **D.** wave action on the emergent shore of a drowned valley.
- **E.** an action unpredictable from the facts presented.

252. (2.10) The arch in the sedimentary strata exposed in the walls of the tributary valley is a structure known as a (an)

A. simple syncline. **B.** simple anticline.
C. geosyncline. **D.** geanticline. **E.** unconformity.

253. (1.10) The change in the color of the shale to red on heating is caused by the

A. hydration of limonite. **B.** reduction of limonite.
C. oxidation of hematite. **D.** oxidation of ferrous iron.
E. reduction of hematite.

254. (2.10) The golden yellow mineral in the vein is probably

A. galena. **B.** limonite. **C.** chalcopyrite.
D. gold. **E.** pyrite.

255. (1.10) The heap of rock debris at the foot of the cliff is called

A. a terrace slope. **B.** an alluvial fan.
C. loess. **D.** talus. **E.** a till slope.

256. (1.10) The ripple marks in the sandstone indicate

- **A.** that the sand was deposited in shallow water.
- **B.** the age of the sediment.
- **C.** that water has flowed over the stone after it has been consolidated.
- **D.** the speed but not the velocity of the water at the time of formation.

257. (1.10) The underclay is characterized as

- **A.** representing an old regolith (soil mantle).
- **B.** being an unconformity.
- **C.** being laid down under marine conditions.
- **D.** being largely sandstone.
- **E.** being largely limestone.

258. (2.10) There is evidence that the ground water table is at the level of

- **A.** the bottom of the main valley.
- **B.** the surface of the water in the main stream.
- **C.** the bottom of the tributary valley.
- **D.** the unjointed sandstone.
- **E.** insufficient evidence is given to locate the ground water table.

259. (1.10) The coal seam was formed by

- **A.** the compaction of sediment deposited below the sea.
- **B.** the compaction of organic matter deposited under swamp-like conditions.
- **C.** the metamorphism of limestone deposits.
- **D.** the metamorphism of soil.
- **E.** none of the above.

Items 260 - 270 refer to the following article extracted from an account by Hugh Miller of his first two days' work in an English quarry in 1841.

The quarry in which I wrought lay on the southern shore of a noble inland bay, or firth rather, with a little clear stream on the one side, and a thick fir wood on the other. It had been opened in the Old Red Sandstone of the district, and was overtopped by a huge bank of diluvial clay, which rose over it in some places to a height of nearly thirty feet, and which at this time was rent and shivered, wherever it presented an open front to the weather, by a recent frost. A heap of loose fragments, which had fallen from above, blocked up the face of the quarry, and my first employment was to clear them away.

(In describing the work of the second day, Miller gives an account of the results of a first day blasting.)

The gunpowder had loosened a large mass in one of the interior strata, and our first employment, on resuming our labors, was to raise it from its bed. I assisted the other workmen in raising it on its edge, and was much struck by the appearance of the platform on which it had rested. The entire surface was ridged and furrowed like a bank of sand that had been left by the tide an hour before. I could trace every bend and curvature, every cross hollow and counter ridge, of the corresponding phenomena; for the resemblance was no half resemblance—it was the thing itself; and I had observed it a hundred and a hundred times, when sailing my little schooner in the shallows left by the ebb. But what has become of the wave that had thus fretted the solid rock, or of what element had they been composed? I felt as completely at fault as Robinson Crusoe did on discovering the print of the man's foot on the sand. The evening furnished me still further cause for wonder. We raised another block in a different part of the quarry, and found that the area of a circular depression in the stratum below was broken and flawed in every direction, as if it had been at the bottom of a pool recently dried up, which had shrunk and split in the hardening. Several large stones came rolling down from the diluvium in the course of the afternoon. They were of different qualities from the sandstone below, and from one another; and, what was more wonderful still, they were all rounded and water-worn, as if they had been tossed about in the sea or the bed of a river for hundreds of years. There could not, surely, be a more conclusive proof that the bank which had enclosed them so long could not have been created on the rock on which it rested. No workman ever manufactures a half-worn article, and the stones were all half-worn! And if not the bank, why then the sandstone underneath? I was lost in conjecture, and found I had food enough for thought that evening, without once thinking of the unhappiness of a life of labour.

260. (1.10) The "heap of loose fragments" removed the first day is the type of deposit designated as

A. talus. **B.** till. **C.** delta. **D.** moraine.
E. loess.

261. (2.20) The type of erosion illustrated in item 260 is

A. exfoliation. **B.** slumping. **C.** chemical.
D. stream erosion. **E.** wind erosion.

262. (2.10) The agency responsible for the transportation of these "loose fragments" is

A. wind. **B.** surface run-off. **C.** ground water.
D. gravity. **E.** ice.

263. (2.10) The "huge bank of diluvial clay" is an example of the type of deposit designated as

A. talus. **B.** till. **C.** delta. **D.** loess. **E.** silt.

264. (2.20) The region in which the quarry is located is

A. the remains of a large delta.
B. the remnant of an ancient loess deposit.
C. the bottom of a large syncline.
D. a region once covered by a glacier.
E. the root of an old mountain.

265. (1.24) The reason for your answer to the two preceding items is

A. the thickness of the deposit of diluvial clay.
B. the fact that the region is underlain by sandstone.
C. some of the material is coarse.
D. the unconsolidated condition of the diluvial clay.
E. the presence of "large stones of different qualities from the sandstone and from each other."

266. (2.10) The large stones referred to as being distributed throughout the diluvial clay are called

A. erratics. **B.** nodules. **C.** fissures. **D.** fossils.
E. stalactites.

267. (2.10) The cementing material in the sandstone is probably

A. calcite. **B.** lignite. **C.** hematite. **D.** garnet.
E. limonite.

268. (4.20) The feature exemplified by the "area of a circular depression" represents

A. ripple marks. **B.** mud cracks.
C. an unconformity. **D.** a fault. **E.** a joint.

269. (4.20) The feature exemplified by the "furrowed and ridged" strata represent

A. ripple marks. **B.** mud cracks.
C. an unconformity. **D.** a fault. **E.** a joint.

270. (2.30) The features in the preceding two items indicate that the region

A. was formerly covered by a shallow sea.
B. was arid with small surface depressions readily blown out by the wind.
C. was at a much higher elevation than at present.
D. is badly folded.
E. is subject to large annual variations of temperature.

271. (2.20) Artesian wells in North Dakota derive their supplies of water from a certain sandstone aquifer. All the following statements but one show why the artesian pressure in wells tapping this aquifer would be apt to differ from place to place. Which statement does *not* apply?

A. Variations in porosity of the aquifer.
B. Variations in permeability of the aquifer.
C. More fractures occur in the capping material in some places than in others.
D. More wells are located in some areas than in other areas.
E. Wells in places with less elevation above the main rivers would have the least artesian pressure.

272. (2.20) Certain parts of the Connecticut Valley to the north of Hanover appear to be wide and open with good sized flood plains and the stream meandering widely across the flood plain. Which one of the following statements *best explains* this condition?

A. Such sections are in old age.
B. Such sections are in the peneplain stage.
C. Such sections are almost at grade.
D. Such sections are just about at the ultimate base level.
E. Such sections are areas in which glacial outwash abounds and therefore the stream can easily meander over it.

Items 273 - 274. The statements below are typical of a certain valley.

1. The valley has a rounded floor and steeply-sloping sides, forming a U-shaped cross-valley profile.
2. The valley is located in a mountainous region.
3. Tributary to the main valley along its course are a number of hanging valleys.

273. The valley features are due probably to the action principally of
(2.20)

A. old-age river gradation. **B.** glacial scouring.
C. wind erosion. **D.** ground-water gradation.
E. youthful river gradation.

274. In which one of the following regions might the above valley be located typically?
(1.10)

A. Southern Chile. **B.** British Guiana.
C. Ontario. **D.** North Dakota. **E.** Southwest Africa.

275. If an artesian well and a surface well are both being pumped in the same local area
(2.30)

A. the pressure drop developed in the artesian well develops a cone of water table depression in the free water horizon.
B. the cone of water table depression developed by the surface well develops a cone of pressure relief in the artesian system.
C. the cone of water table depression developed by the surface well reduces the amount of water that enters the artesian system.
D. the pressure drop developed in the artesian well causes water to seep from the ground water reservoir into the artesian aquifer.
E. the wells have no effect on each other.

276. A river which has many well-developed tributaries and which shows lateral erosion would also be expected to be characterized by
(2.30)

A. extensive falls and rapids. **B.** V-shaped walls.
C. a very steep gradient.
D. few very broad and sharply cut divides.
E. comparatively numerous, narrow, well-rounded divides.

277. Consider the case of a stream like the Mississippi River but *without* any man-made conditions as dikes, fuse-plug levees, artificial cut-offs, etc., to interfere with natural processes of stream action. With the passing of centuries and milleniums such a stream would
(2.30)

A. tend to produce fewer oxbow lakes.
B. tend to form oxbow lakes that would be very long-lived.
C. become straighter since natural cut-offs would straighten it.
D. become more crooked since the gradient of the flood plain becomes flatter and hence the stream would swing more and more.
E. none of the above.

278. In general, sea cliffs cut in morainic material have a seaward slope because
(2.40)

A. the cliffs are easily undercut by longshore currents.
B. the cliffs are generally in massive rock without joints or planes of weakness.
C. undertow and currents remove the loose material as fast as it falls from the cliff and weathering is extremely effective on the upper part of the cliff.
D. the wave cut bench is too wide for the undertow to carry the material away.
E. the material has joint planes which slope towards the sea.

279. If two streams, X and Y, drain neighboring areas, the drainage of X could be captured by Y if
(3.00)

A. the gradient of the two streams is the same.
B. the gradient of X is greater than that of Y.
C. Y has a shorter route to the sea.
D. X has a shorter route to the sea.
E. X has greater erosive power.

280. At Grand Ledge the base of the massive sandstone is saturated with water. Underneath the sandstone is a layer of shale. The *best* explanation of this saturated condition is that
(3.00)

A. the shale pore spaces are very small.
B. the sandstone has many joints.
C. the shale-sandstone contact is at the water level of the stream.
D. capillary action causes the water to rise above the water table.
E. shale is not porous.

281. A given stream channel has a width of 40 feet; depth of 20 feet (with vertical banks); slope of 10 feet per 100 feet. Two different stages of flow are recorded:
(3.00)

1. September 15—water is 5 feet deep in the channel.
2. October 15—the water is 15 feet deep in the channel.

The relative velocity at stage 2 is

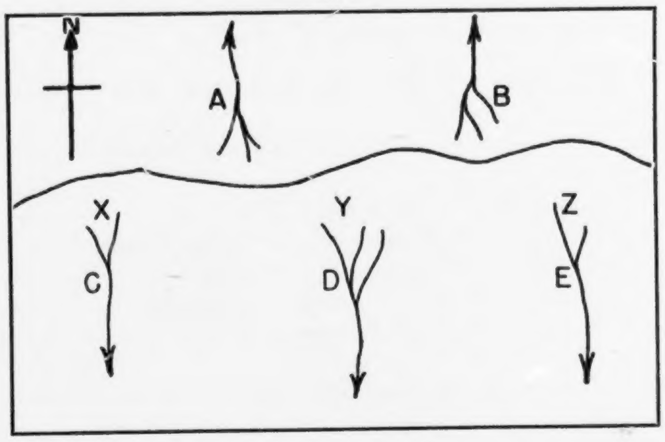
A. one-half that at stage 1.
B. about 4 times that at stage 1.
C. about 10 times that at stage 1.
D. about 8 times that at stage 1. **E.** none of these.

282. A given irregular shore line extends approximately north to south with the sea to the east of the land. At point X there is a rocky cliff composed of granite. Just to the north of this beach is a cove and beach (B) extending for 2 miles and at the north end of this beach is a high headland (Y) composed of morainic material. The prevailing wind direction along this coast is southeast. If you were in need of large quantities of sand for construction purposes you would probably find them
(3.00)

A. south of point X.
B. stretching from point X northward along the shore of the cove and beach to point Y.
C. stretching from headland Y southward along the shore of the cove and beach to point Y.
D. some little distance north of headland Y.
E. none of the above.

For items 283 and 284 refer to the following diagram.

Fig. 1



283. The map above shows an area with E–W divide, and streams A, B, C, D, and E. After being developed to the stage of maturity the area was glaciated. Assume that the area had been occupied by an ice sheet moving from north to south rather than by valley glaciers. Scale of map: 1 inch = 10 miles.
(3.00)

Which one of the following would be good evidence that the assumption just stated is correct?

- **A.** Drumlins in valleys of streams C, D, and E but none in the valleys of streams A and B.
- **B.** Erratics from points X, Y, and Z found farther down stream in valleys of C, D, and E, respectively.
- **C.** Several recessional moraines in each of valleys C, D, and E, and these moraines are convex to the south. No recessional moraines in valleys A and B.
- **D.** Recessional moraines in *all* of the valleys, and convex to the north in valleys A and B, while in valleys C, D, and E they are convex to the south.
- **E.** Recessional moraines in *all* of the valleys, and in all cases such recessional moraines are convex to the south.

284. (3.00) *Refer again to Fig. 1.* Assume that the area had been occupied by valley glaciers rather than by an ice sheet. Which one of the following would be *good evidence* that the assumption just stated is correct?

- **A.** Sheep rocks *(roches moutonees)* in all valleys, with quarried or plucked side to the north in valleys A and B, and with quarried side to the south in valleys C, D, and E.
- **B.** No recessional moraines in any of the valleys.
- **C.** Drumlins in each valley with blunt end to the north in each case.
- **D.** No eskers in any of the valleys.
- **E.** Erratics from valleys A and B found south of the divide in valleys C, D, and E.

285. (3.00) Ordinarily in a boulder train the *percentage* of the particular erratics making up the train decreases steadily as you go from the source towards *the farthest limit of the train.* Occasionally, however, some rather high percentages of the erratics occur some distance away from the source and separated from it by localities with smaller percentages of the erratics. This might be due to

- **A.** greater resistance of the erratics in that particular locality with high percentage and weathering being unable to crumble them.
- **B.** a change in direction of motion of the ice from time to time.
- **C.** another ledge of the same kind of rock which supplied the fragments but which ledge is now hidden by the drift.
- **D.** a stream which after the ice had disappeared, flowed in a direction transverse to the boulder train and washed away most of the erratics except at that particular spot.
- **E.** none of the above.

286. (3.00) In the study of archeology much information concerning the habits and manner of life of early people may be derived from excavations and hence the discoveries of utensils and fragments of tools, etc. In the United States and Europe which of the following would you consider to be *least productive* in the yield of such materials, provided you had the time and money to carry on the excavation?

A. Eskers. **B.** Cave deposits.
C. Flood plain deposits. **D.** Loess deposits.
E. Peat bogs.

Items 287 - 297 contain statements which may be true or false and reasons or causes which may support the statement, not support it, contradict it, or be immaterial. For each item select from the key the correct response.

KEY

- **A.** The statement is true; the reason supports it.
- **B.** The statement is true; the reason does *not* support it.
- **C.** The statement is false; the reason supports the *contrary.*
- **D.** The statement is false; the reason is immaterial.

287. (4.20) If either the source of waves or the observer move with respect to the other, the apparent frequency changes.

Reason: Diffraction changes the frequency.

288. (4.20) The angle of repose for sedimentary deposition in air is about 32°.

Reason: At a greater angle gravity would cause slumping.

289. (4.20) Sulphur may have a negative valence.

Reason: Its compounds are made by sharing electrons.

290. (4.20) Geosynclines are very complex structures.

Reason: They are creased by secondary folds.

291. (4.20) The formation of calcareous tufa on rock surfaces is called exfoliation.

Reason: The water seeping through the rock contains dissolved sodium bicarbonate.

292. (4.20) Endothermic reactions proceed spontaneously.

Reason: They absorb energy.

293. (4.20) Two stages of development in a stream may appear in the same valley.

Reason: If the land surface is lowered an increased gradient is given to the streams.

294. (4.20) $Ca(HCO)_2$ in solution is unstable and may change to $CaCO_3$.

Reason: When pressure is applied, CO_2 will be given off.

295. (4.20) Granite may be extremely fine grained.

Reason: The magma from which it formed cooled off very slowly.

296. (4.20) If two short wires of copper and iron, equal in length and cross section, are connected in parallel to a dry cell, the iron will become hotter.

Reason: Iron has a higher resistance.

297. (6.20) Goldsmith's "History of the Earth," printed in 1795 says: "It is said of rivers that they run in a more direct channel as they immediately leave their sources, and that their sinuosities and turnings become more numerous as they proceed. It is a certain sign among the savages of North America that they are near the sea when they find the rivers winding and every now and then changing their direction."

Consider this statement with reference to New England, and select the one correct statement from those listed below.

- **A.** The quotation is correct because New England's large rivers flow from north to south and therefore show more tendency to meander due to the earth's rotation.

B. The quotation is correct because the entire New England area · is covered with a thick layer of residual soil which masks the underlying bedrock and presents gentle slopes permitting the streams to meander.

C. The quotation is correct because the outcrops of bedrock occur only on the hill tops and would therefore have no influence on the meandering of streams.

D. The quotation is false because all New England river valleys are steep walled and the channels usually have steep slopes everywhere, giving no chance for the stream to meander greatly.

E. The quotation is false because New England rivers in general have valleys which consist of sections with narrow rocky beds and gorge-like valleys interspersed with sections of broad, open, flat valleys. Hence the meandering sections may occur near the sea or far from it depending on the character of the stream valley and its bed in different localities.

298. Which one of the following statements is correct?
(6.20)

A. No matter what the make-up of the shore line material, the hydraulic action of the waves on that shore line is the chief means by which the shore material is disrupted and torn away.

B. On a shore line composed of unconsolidated material stacks often form and generally last for a long time (reckoned geologically).

C. Sea caves may be reliable evidence of former positions of sea level.

D. The extreme tip end of a spit would rarely, if ever, show anything concerning the direction of shore currents.

E. Bay bars never reach a height of more than a foot or two above sea level, since they are formed by the oncoming waves dragging material towards shore.

8. *Erosion, Sedimentation, and Weathering*

EROSION, SEDIMENTATION, AND WEATHERING

1. (1.10) The erosive power of a stream is dependent on all of the following factors *except*

A. the velocity of the stream.
B. the volume of water in the stream.
C. the quantity of matter carried in solution by the stream.
D. the quantity of matter carried in suspension by the stream.
E. the nature of the material carried in suspension by the stream.

2. (1.10) Of all the sedimentary deposits now existing on the earth's surface, by far the greatest volume was formed by

A. fresh-water deposition. **B.** wind deposition.
C. glacial deposition. **D.** marine deposition.
E. some other means than listed above.

3. (1.10) One of the main reasons for the effective role that water plays in the physical disintegration of rocks concerns its

A. presence in solid, liquid, and gas forms on the surface of the earth.
B. ability to dissolve carbon dioxide.
C. high specific heat. **D.** high surface tension.
E. expansion on freezing.

4. (1.10) Frost action as a mechanical agent of weathering is most active in

A. temperate regions. **B.** polar regions.
C. arid regions. **D.** tropical regions.
E. sub-tropic regions.

5. (1.10) In the present era the most important gradational agent is

A. winds. **B.** water. **C.** glaciers.
D. diastrophism. **E.** volcanism.

6. (1.10) Wind as an agent of erosion is most active in

A. maritime regions. **B.** polar regions.
C. arid and semi-arid regions.
D. tropical regions. **E.** moist regions.

7. (1.10) The depositional feature produced where a stream flows into a standing body of water is called

A. a flood plain. **B.** an alluvial fan.
C. an esker. **D.** a delta. **E.** a glacier.

8. (1.10) The fretting or pitting in the thin beds of sandstone in the Grand Ledge area is the result of

A. ground water solution.
B. differential weathering. **C.** decomposition.
D. erosion by the Grand River.
E. scouring by the glacier.

9. (1.10) The face of the cliff at Grand Ledge has a thin zone of wavy or crenulated shale that forms the break between the lower massive sandstone and the thin-bedded sandstone above. Such a feature is known as

A. an unconformity. **B.** incompetent bedding.
C. a colluvial deposit. **D.** underclay.
E. a confluence.

10. (1.10) An erosional unconformity is evidence of

A. the former presence of glaciers.
B. volcanic action in the region.
C. the different hardness of rocks in the area.
D. the existence of a period of time for which the rock record is incomplete.
E. the occurrence of metamorphosis.

11. (1.10) Silt and mud deposited parallel to a river when it overflows form ridges called

A. eskers. **B.** dikes. **C.** monoclines.
D. natural levees. **E.** deltas.

12. (1.10) The chief product of rock decomposition is

A. clay. **B.** sand. **C.** humus. **D.** potash.
E. shale.

13. (1.10) Generally speaking, the material immediately beneath a coal seam is an underclay which is characterized as

A. representing an old regolith.
B. being an unconformity.
C. being largely sandstone.
D. being laid down under marine conditions.
E. being largely limestone.

14. (1.10) An irregular surface separating two series of rocks is called a (an)

A. unconformity. **B.** terrace. **C.** moraine.
D. beach. **E.** paleozoic remnant.

For items 15 - 23 select from the key the agent which produced the structure or effect named in the item.

KEY

A. Weathering. **B.** Wind. **C.** Ground water.
D. Running water. **E.** Glaciers.

15. (1.10) Exfoliation. **16.** (1.10) Dunes. **17.** (1.10) Sinkholes.

18. (1.10) Soil. **19.** (1.10) Cirques. **20.** (1.10) Peneplain.

21. (1.10) Geodes. **22.** (1.10) Moraines. **23.** (1.10) Drumlins.

24. (1.10) In the Grand Ledge area, marine inundation is evidenced by

A. coal deposits. **B.** underclay.
C. black limestone.
D. sandstone containing plant remains.
E. glacial drift.

25. (1.10) Rock salt deposits in the earth were formed

A. from calcite.
B. from the metamorphism of igneous rocks.
C. by neutralization of NaOH in the rocks with HCl.
D. by the cooling of molten halite.
E. by the evaporation of sea water.

26. (1.10) If you went south beyond the region affected by glacial action, you would encounter

A. U-shaped valleys.
B. smoothed, fluted, and striated bedrock.

C. hanging tributary valleys.
D. talus slopes. **E.** outwash plains.

27. (1.10) Weathering and gradation of the land surface is collectively known as

A. exfoliation. **B.** erosion. **C.** disintegration.
D. decomposition. **E.** slumping.

28. (1.10) The geologic agent in the deposition of loess is

A. glaciation. **B.** ground water.
C. running water. **D.** waves. **E.** wind.

29. (1.10) A chief product of chemical weathering is

A. clay. **B.** mica. **C.** gypsum. **D.** slate.
E. feldspar.

30. (1.10)
1. In arid regions the most active agent of erosion is wind.
2. Streams generally flow in valleys which they have eroded.
3. Glacial valleys are U-shaped in cross section.

Which one of the following lists all and only those statements above which are true?

A. 1. **B.** 2. **C.** 1 and 2. **D.** 2 and 3.
E. 1, 2, and 3.

31. (1.10) A general term for coarsely graded sediments, extremely heterogeneous, of glacial origin and generally unstratified drift is

A. slate. **B.** talus. **C.** moraines. **D.** till.
E. none of these.

32. (1.10) The presence of granite and quartzite boulders in the regolith of the Grand Ledge area is evidence of

A. glacial activity.
B. igneous intrusion in the area.
C. marine invasion.
D. regional folding and metamorphism.
E. faulting.

For items 33 - 37 match the item to the key.

KEY

A. Result of weathering.
B. Result of wind action.
C. Result of ground water.
D. Result of running water.
E. Result of glaciers.

33. (1.10) Cirques.
34. (1.10) Fjords.
35. (1.10) Loess.
36. (1.10) Exfoliation.
37. (1.10) Soil.

Items 38 - 45 are the result of certain geologic actions. For each item select from the key the action which caused it.

KEY

A. Weathering. **B.** Wind. **C.** Ground water.
D. Running water. **E.** Glaciation.

38. (1.10) Hamadas.
39. (1.10) Frost wedging.
40. (1.10) Peneplain.
41. (1.10) Serrate divides.
42. (1.10) Loess.
43. (1.10) Exfoliation.
44. (1.10) Outwash plains.
45. (1.10) Stalagmites.

46. (1.10) Two important types of weathering are disintegration and decomposition. Which one of the following should be classed as disintegration? The results of

A. Oxidation. **B.** Carbonation. **C.** Solution.
D. Freezing. **E.** Hydration.

47. (1.10) A term suggesting glacial action is

A. hamada. **B.** playa. **C.** monadnock.
D. cirque. **E.** paludal.

48. (1.10) Peneplaination is basically a function of

A. weathering. **B.** wind action.
C. ground water action.
D. the action of running water. **E.** glacial action.

49. (1.10) Cirques are

A. developed in water eroded valleys.
B. developed by the plucking action of mountain glaciers.
C. dust bowls formed by the wind action in dust storms.
D. formed at the foot of canyon walls in youthful valleys.
E. developed largely by the abrasive action of glaciers.

50. (1.10) One of the best evidences of glacial action in a region would be shown by

A. talus heaps at the foot of rock walls.
B. undercutting. **C.** erratics.
D. cross bedding. **E.** exfoliation.

51. (1.10) A term suggesting glacial action is

A. talus slope. **B.** stalagmites. **C.** hamada.
D. continental shelf. **E.** hanging valley.

52. (1.10) In marine erosion differential action causes the formation of the following:

A. Coves. **B.** Caves. **C.** Blowholes. **D.** Arches.

53. (1.10) It can be told whether ancient sediments were laid down in water which was rising higher on the land by

A. the size of particles in the sediment.
B. the overlay of the higher sediments.
C. the geographical orientation of the dip and strike of the bed.
D. the fossils in the sediment.

54. (1.10) In South Dakota and Wyoming one can drive for many miles through land so cut up by small gullies that it is impossible to find a spot level enough to farm. These are known as the "Badlands." These features show the result of erosion by

A. ground water. **B.** running water. **C.** ice.
D. shore agents. **E.** glacial action.

55. (1.10) Mountains can be formed by

A. complex folding and faulting.
B. erosion. **C.** volcanism.
D. both folding and faulting, but not erosion.
E. all of the preceding including erosion.

56. The *difference* between a moraine and an esker is that
(1.10)

- **A.** a moraine is formed by glacial action, whereas an esker has no connection with glaciers.
- **B.** moraines are produced only when glaciers melt, but eskers result from the sheering force of a moving glacier.
- **C.** a moraine is made up of igneous rocks, whereas an esker is formed of sedimentary rock.
- **D.** moraines are ridges of rock debris deposited at the sides or ends of glaciers, whereas eskers are ridges deposited by sub-glacial streams.
- **E.** moraines may be terminal or lateral, but eskers are only lateral.

57. An unconformity indicates
(1.10)

- **A.** deposition of large quantities of unsorted material in geosynclines.
- **B.** that a transitory feature definitely existed in the area at one time.
- **C.** a long period of erosion followed by submergence and sedimentation.
- **D.** that igneous rock is usually beneath the sedimentary layers.
- **E.** that mountains have been produced at one time due to differential erosion.

58. The *difference* between cirques and striae.
(1.10)

- **A.** The latter but not the former may be taken as evidence of the former presence of a glacier.
- **B.** The former are examples of glacio-fluvial deposits, while the latter are streaks in rocks due to varying crystalline structure.
- **C.** The former are amphitheater-like depressions cut by glacial ice at the heads of valleys while the latter are glacial scratches on rocks.
- **D.** Cirques are hanging valleys while striae are types of eskers.
- **E.** A cirque is a crevasse while a striae is a crack.

59. The most logical explanation of the formation of ox-bow
(1.10) lakes is

- **A.** the persistence of lagoons upon the mergence of shore lines.
- **B.** the straightening out (cutting through) of an old meandering river, thereby leaving remnants of old meanders.
- **C.** underground springs oozing towards the surface.
- **D.** geologic changes in climate causing a formerly rainy region to become relatively dry.
- **E.** the melting of glaciers.

60. Three and no more than three of the following items
(1.10) belong to a common category: cirques, sand bars, meanders, ground moraines, sink holes, hanging valleys. The common category is concerned with landscape features that are due mainly to

- **A.** gradation by ground water.
- **B.** gradation by old age streams.
- **C.** gradation by mature streams.
- **D.** gradation by winds. **E.** glacial gradation.

61. Which of the following attains a maximum during the
(1.10) mature stage of river development in a region?

- **A.** Hilliness or ruggedness of the landscape.
- **B.** Velocities of main rivers. **C.** Meandering.
- **D.** Prevalence of rapids.
- **E.** Area of interfluvial summits.

62. If an equal amount of rain falls upon one square mile
(1.10) of each of the following areas, which one will deliver the greatest quantity of water to the natural reservoir in the ground, i.e., as ground water beneath the ground water table?

- **A.** Chicago.
- **B.** Plowed or cultivated fields of farms.
- **C.** Forest land.
- **D.** Neglected over-grazed meadowland.
- **E.** Deserted and neglected land of any kind.

For items 63 - 65 assume that you are standing on a mound of unsorted sand and gravel in a steep-sided canyon and that the canyon is U-shaped as you look upstream.

63. The type of formation you are standing on was probably
(1.10) caused by

- **A.** ground water. **B.** weathering.
- **C.** running water. **D.** glacier action.
- **E.** shore agents.

64. The mound of sand and gravel is probably
(1.10)

- **A.** an alluvial fan. **B.** a wave cut terrace.
- **C.** a hanging valley. **D.** a sinkhole.
- **E.** a moraine.

65. Upstream from this mound you would expect to see
(2.30)

- **A.** caves. **B.** sand bars. **C.** hanging valleys.
- **D.** meanders. **E.** ox-bows.

Items 66 - 75. After each item number on the answer sheet, blacken the *one* lettered space which designates the geological agent primarily responsible for the geological feature named in the item.

A. Wind. **B.** Ground water. **C.** Glaciers.
D. Running water.

66. (1.10) Delta. **67.** (1.10) Geode. **68.** (1.10) Natural levee.

69. (1.10) Loess. **70.** (1.10) Geyser. **71.** (1.10) Esker.

72. (1.10) Hanging valley. **73.** (1.10) Alluvial deposits.

74. (1.10) Mineral vein. **75.** (1.10) Stalactite.

For items 76 - 81 select from the key the correct title for the definition given in each item.

KEY

A. Alluvial fan. **B.** Loess. **C.** Bedding.
D. Foliation. **E.** None of these.

76. A type of cyclic (annual) stratification used in deter-
(1.10) mining glacial time.

77. Crystallization or re-crystallization of metamorphic rocks
(1.10) producing alignment or segregation of minerals into bands.

78. Buff-colored, wind-blown deposit of fine silt usually
(1.10) unstratified, which is often exposed in bluffs.

79. Long and often winding ridges formed of stratified sand
(1.10) and gravel occurring in glaciated regions.

80. The layering or stratification of sediments and sedi-
(1.10) mentary rocks sometimes shown by bands of color in very fine-grained sediments.

81. Cone-shaped to delta-shaped deposits of poorly sorted
(1.10) clastic sediments deposited by intermittent streams that debouch from steep valleys on to relatively gentle plains or slopes.

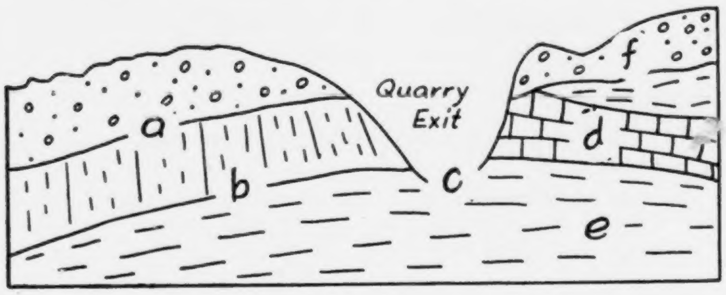
82. When thin slabs of sandstone scale off from a cliff, this
(1.10) process is known as

A. exfoliation. **B.** slumping. **C.** thin bedding.
D. undercutting. **E.** crenulation.

83. Talus blocks of sandstone at the base of cliffs were
(1.10) transported by

A. the river. **B.** the glacier. **C.** the ocean.
D. the wind. **E.** gravity.

Items 84 - 87 are based on the following diagram.



84. An unconformity is shown by
(1.10)

A. a. **B.** b. **C.** c. **D.** d. **E.** none of these.

85. The material at the bottom of the diagram is
(1.10)

A. drift. **B.** limestone. **C.** shale.
D. sandstone. **E.** granite.

86. Limestone is present at
(1.10)

A. f. **B.** g. **C.** e. **D.** d. **E.** none of these.

87. The fact that the quarry was under the sea at one time
(1.10) is shown by

- **A.** the shape of the quarry.
- **B.** the change in color of the brick made from the shale deposited here.
- **C.** the coal formations.
- **D.** the remains of brachiopod called Lingula in the shale.
- **E.** the presence of salt water at the base of the quarry.

88. Which one of the following statements concerning the
(1.10) thickness of residual mantle would be *incorrect?*

- **A.** It is thickest in the desert area of the southwest United States.
- **B.** It is thinner in northern New England than in Central America.
- **C.** It would be thicker in Georgia than in northern Illinois.
- **D.** It would be thinner in southern New England than in the Pacific northwest.
- **E.** It would be thinner around Hudson Bay than in South Carolina.

89. Streams are apt to deposit the load they are carrying
(1.10)

- **A.** if the volume of the stream increases.
- **B.** in places where the channel is straighter and deeper.
- **C.** if the stream empties into a body of quiet water.
- **D.** if the slope of the bed of the channel is increased.
- **E.** if the stream is affected by the rotation of the earth.

90. Which one of the following statements is correct?
(1.10) Stream divides

- **A.** are always ridged in the old age stage of development.
- **B.** shift in position towards the larger stream.
- **C.** become sharper in character after maturity.
- **D.** lose height rapidly during youth.
- **E.** do not shift much in location during the old age stage.

91. Solifluction is most likely to occur in which one of the
(1.10) following places?

- **A.** On a flat flood plain in a humid region.
- **B.** On a pediment in an arid region.
- **C.** On a moderately steep slope in clay in New England.
- **D.** On a granite mountain peak in the Rocky Mountains.
- **E.** None of the above.

92. All but one of the following are primarily the result of
(1.10) weathering aided by gravity. Which one is the exception?

A. Talus. **B.** Landslides. **C.** Rock streams.
D. Imbrication. **E.** Creep.

93. Most sediments today are being accumulated in or on
(1.10)

A. lakes. **B.** stream beds.
C. at the base of mountains.
D. continental shelves. **E.** ocean basins.

94. Which one of the following statements is correct con-
(1.10) cerning sand dunes?

- **A.** The sand grains are always very minute in size since they are wind blown.
- **B.** The number of layers of sand in a vertical section of the front of the dune enables us to tell the number of years it took to form the dune.
- **C.** The sand dunes always advance at a regular rate of speed.
- **D.** The height to which dunes may grow depends largely upon the strength of the wind.
- **E.** The back of a dune always shows the steeper slope.

95. Barrier beaches (off-shore bars) usually occur under
(1.10) which one of the following conditions?

- **A.** Areas in which the undertow is notably strong and therefore such beaches are built solely by the undertow.
- **B.** Areas where the longshore currents are dominantly in one direction and of great strength.
- **C.** Where stacks and blowholes are exceptionally numerous.
- **D.** Along a rather low, gently sloping coast where the undertow can combine its effects with the work of waves advancing shoreward.
- **E.** Where the water offshore is very deep and no waves can break before reaching the shore.

96. All the following except one are due to erosion. Which
(1.10) one is the exception?

A. Buttes. **B.** Potholes. **C.** Mesas.
D. Ventifacts. **E.** Kettle holes.

97. All of the following except one are due to deposition.
(1.10) Which one is the exception?

A. Boulder clay. **B.** Natural levees.
C. Stalagmites. **D.** Tombolos. **E.** Nunataks.

98. In the humid cycle of erosion during the change from (1.22) maturity to old age

A. meanders become smaller due to shrinkage of stream flow.
B. the valleys remain the same width because not so much water flows in the streams.
C. more material is ordinarily carried in suspension or by saltation because being finer it can be picked up more readily.
D. meanders and meander belts become larger.
E. piracy occurs very often since the streams do not have to cut headward so far to tap another river system.

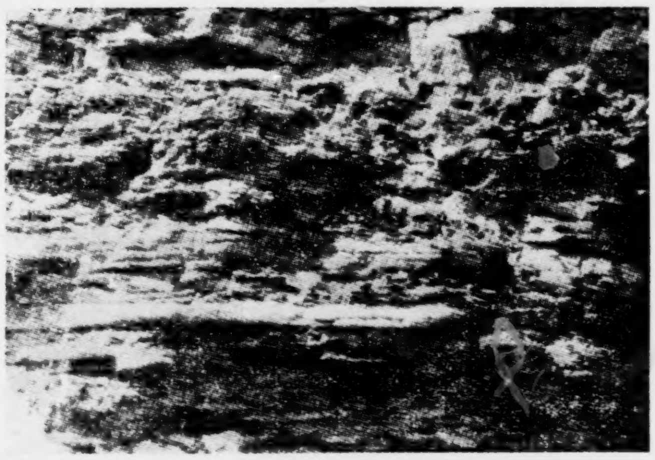
99. In the arid cycle of erosion during the change from (1.22) youth to maturity the same conditions of development occur as they do in humid regions except that

A. the streams grow shorter due to the building of alluvial fans.
B. the relief decreases due to filling of basins and reduction of highlands.
C. stream piracy develops more rapidly in the arid regions than under humid conditions.
D. lakes tend to remain in one place and grow deeper.
E. none of the above.

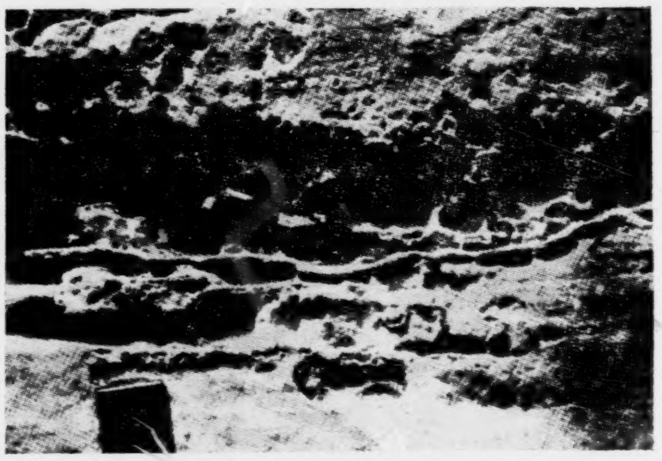
100. Hobb's Glacial Anticyclone Theory for nourishment of (1.30) an ice sheet assumes which one of the following?

A. The weather over the center of an ice sheet is always like a blizzard in nature.
B. The warm moisture bearing air rises periodically over the central parts of the ice sheets causing more snow to fall.
C. The winds which are warm and carrying moisture blow periodically and easterly across an ice sheet and thus add snow to it.
D. The air in contact with the ice is chilled by the ice and flows outward while moisture bearing air flows in towards the center at high levels and is drawn down towards the ice thus giving snow to the central parts.
E. The only winds present at any time are those which blow from the margins towards the center of the ice sheet.

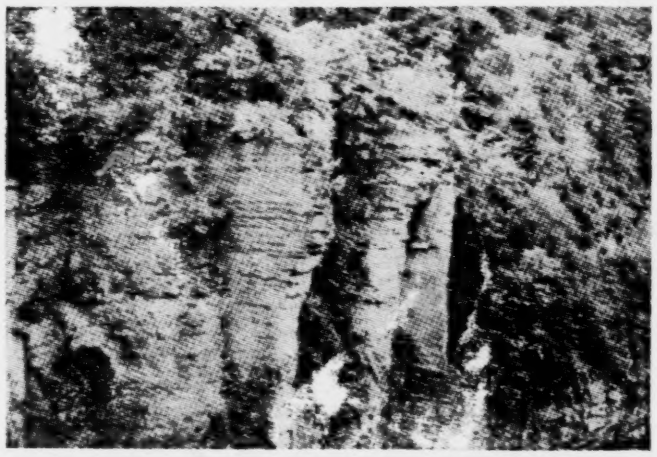
Items 101 - 105 are based on the photographs appearing on page 470.



–A–



–B–



– C –

–D–

–E–

–F–

101. (2.10) The rock in A is

A. marble. **B.** igneous. **C.** slate.
D. sedimentary. **E.** conglomerate.

102. (2.10) Photograph B presents evidence of

A. durability. **B.** a secondary erosion cycle.
C. differential weathering. **D.** erosional unconformity.
E. stylolite structure.

103. (2.10) The "buttresses" of photograph C were formed by

A. weathering between joint planes.
B. igneous activity. **C.** faulting.
D. metamorphism. **E.** differential solution.

104. (1.10) The most prominent geologic feature in photograph D is

A. a cirque. **B.** a dike. **C.** a syncline.
D. an anticline. **E.** an unconformity.

105. (2.20) Photograph E shows unconsolidated material of glacial origin resting on a floor of bedrock. A close view of this material is given in photograph F. One reason that this material is considered glacial is that it

A. grades imperceptibly into the underlying rock.
B. has undecomposed stones in it.
C. is a mixture of finely divided material mixed with rocks of all sizes.
D. has stream rounded rocks in it.
E. contains humus.

106. (2.10) A sand dune with many spurs pointing in various directions would be common in regions in which

A. supply of sand is scanty and winds are strong.
B. winds are strong and steady in direction.
C. winds are variable in strength and direction.
D. winds are weak but steady in direction.
E. none of the above.

107. (2.20) Region X contains many lakes which rest on bedrock. Many large boulders of various kinds of rock abound in the area. The top soil has completely disappeared in some parts of the region, leaving the bedrock exposed. Region X most likely

A. recently emerged from the sea.
B. was scoured by a glacier.
C. is a delta.
D. was modified by underground stream erosion.
E. is the valley of an ancient stream which eroded it.

For items 108 - 110 choose from the key list of processes of decomposition the one most closely related to the word equations.

KEY

A. Oxidation. **B.** Carbonation. **C.** Hydration.
D. Solution.

108. (2.20) Orthoclase plus water plus carbon dioxide yields kaolin plus silica plus potassium carbonate.

109. (2.20) Anhydrous calcium sulphate plus water yields gypsum.

110. (2.20) Calcite plus water plus carbon dioxide yields calcium bicarbonate.

For items 111 - 114 choose from the key list of agents of erosion the agent or combination of agents responsible for the situations comprising items 111 - 114.

KEY

A. Wind activity and running water.
B. Wind activity and ice activity.
C. Wind activity alone. **D.** Running water alone.
E. Ice activity.

111. (2.20) Well frosted sand particles accumulate in transitory hills and mounts.

112. (2.20) Rock outcrops may be undercut near their lower surfaces.

113. (2.20) Exceptionally rugged peaks and sharp ridges are characteristic of certain mountain areas.

114. (2.20) The deposits of eroded materials show cross bedding.

115. (2.20) In the arid cycle of erosion subsequent streams are less often well developed than in the humid cycle of erosion. This is due to the fact that in arid regions

A. the weaker rocks in the basins are buried by waste and consequently the streams cannot cut down along such weak rocks.
B. the slopes are so gentle that stream piracy cannot occur and hence subsequent streams cannot develop so well.
C. the development of the area is so rapid that there is not enough time for the formation of subsequent streams.
D. drainage is centripetal and therefore subsequent streams could not develop.
E. none of the above.

116. (2.40) The last ice age came to an end approximately 20,000 years ago. At the present time, most geologic experts agree that the polar ice is still melting and raising the level of the oceans about 2½ inches per century. The cause of the ice ages probably was

A. variations in the amount of energy produced by the sun.
B. geologic changes producing alternation between broad oceans (much evaporation and much snowfall) and smaller oceans (less evaporation and less snowfall).
C. variations in the average temperature due to changes in the earth's orbit.
D. a shift in the icy areas due to a change in the positions of the poles.
E. No completely satisfactory explanation of the cause of the ice ages has been proposed.

117. (2.40) In California, on a certain river, one looks downstream and sees a V-shaped valley. Upstream the valley is smooth and U-shaped. One must be standing on the present or former location of

A. a terminal moraine. **B.** a sand-bar. **C.** a spit.
D. a dam. **E.** a hook.

118. (3.00) A cliff of relatively porous rocks stands in a region where there are considerable variations in temperature. Here one would expect to find

A. loess. **B.** talus. **C.** alluvial deposits.
D. faults. **E.** eskers.

119. (4.20) After noting that the average diameter of the sediments in the Rhine River channel decreased uniformly downstream from 20 mm. to 1 mm. in 100 miles, a geologist conducted an experiment in which he abraded gravel of 20 mm. diameter in water in a horizontal rotating barrel. After rotating the barrel for a length of time such that the gravel fragments traveled 100 miles, he found that their average diameter had decreased to 4 mm. A justifiable conclusion would be that

A. abrasion is not an important process in streams.
B. the average size of the sediments contributed to the Rhine River from the valley walls must decrease downstream.
C. breaking of particles by impact against each other must be the process by which the average size decreased in the Rhine channel.
D. the Rhine River sorts its particles according to their size.
E. abrasion is not responsible for all the changes in particle size in stream beds.

120. (4.20) Along the east bluff of Devil's Lake, Wisconsin, are numerous blocks of quartzite rock which have evidently tumbled down from the cliff above. It is most probable that this is the result of

A. glaciation. **B.** wind erosion.
C. repeated freezing and thawing.
D. the action of running water.

Items 121 - 143. Below are some statements which are true. Following each statement are a number of items which are not necessarily true. On the answer sheet in the space corresponding to the numbers of the items blacken space

A. if the item presents evidence which supports the statement.
B. if the item presents evidence which contradicts the statement.
C. if the item presents evidence which has no bearing on the statement.
D. if the item is an hypothesis.
E. if the item is a definition.

Statement: A large glacier covered Chicagoland during recent geologic time.

121. (4.20) The bedrock upon which Chicago stands is limestone.

122. (4.20) "Dump" deposits—low hills and ridges and irregular undrained hollows—similar to those around Chicago are found in presently glaciated regions of the Alps and Rockies.

123. (4.20) A terminal moraine is the deposit left at the end of a glacier, when the rate of advance equals the rate of melting for a considerable time.

124. (4.20) Perhaps the glacial age was caused by volcanic dust in the atmosphere, which cut off the sun's heat and light from the earth.

125. (4.20) The low hills and depressions around the Chicago area exhibit a composition of unsorted material.

126. (4.20) The Chicago plain is characterized by a thin layer of top soil containing no other constituents than the underlying rock strata.

Statement: The glacier which once covered Chicagoland moved from northeast to southwest.

127. (4.20) Many parallel grooves and scratches are found on bedrock running from northwest to southeast.

128. (4.20) A valley glacier is a river of ice.

129. (4.20) The many moraine ridges in Chicagoland curve around the shore of Lake Michigan to the south and west.

130. (4.20) Great sand dunes are found today on the southeast and east shores of Lake Michigan.

131. (4.20) Found in the debris covering Chicago are fragments of rock native to Minnesota.

132. (4.20) A region in Wisconsin free of drift, called the driftless area, is assumed never to have been covered by the glacier.

133. (4.20) The glacier which covered Chicagoland possibly originated in Newfoundland.

Statement: The plain upon which Chicago now stands was once the bottom of a large lake.

134. (4.20) Perhaps the lake was formed from glacial meltwater.

135. (4.20) Several series of low cliffs stand on the Chicago plain. These are parallel to and face the present lake shore.

136. (4.20) A well developed river channel which led to the Illinois River served as drainage outlet for the lake.

137. (4.20) Blue Island is identified as such by remnants of its surrounding shoreline and of sand dunes on its west-facing side.

138. (4.20) Grooves cut when a glacier dragged a rock over the face of another are known as "glacial striae."

Statement: The St. Peter sandstone of Starved Rock was formed before the Niagara limestone on which Chicago stands.

139. (4.20) There are outcrops of Niagara limestone near Niagara Falls.

140. (4.20) Niagara limestone contains a number of structures very similar to buried coral reefs.

141. (4.20) In Ohio, St. Peter sandstone is found above Niagara limestone.

142. (4.20) Both St. Peter sandstone and Niagara limestone are sedimentary rocks.

143. (4.20) Wells dug in the Chicago area strike first Niagara limestone and then, considerably deeper, St. Peter sandstone.

9. *Weather and Climate*

WEATHER AND CLIMATE

1. (1.10) A modification of which of the following instruments is needed in measuring relative humidity?

A. Thermometer. **B.** Calorimeter. **C.** Barometer.
D. Seismograph. **E.** Anemometer.

2. (1.22) Which of the following pairs of things can be measured by essentially the same instrument?

A. Altitude and relative humidity.
B. Temperature and atmospheric pressure.
C. Atmospheric pressure and altitude.
D. Wind velocity and relative humidity.
E. Wind velocity and atmospheric pressure.

2a. (3.00) The N.E. trade winds blow toward the southwest while the S.E. trade winds blow northwest. This is true

A. because the earth rotates toward the west.
B. only because the earth rotates toward the east.
C. because the anti-trade winds are deflected eastward.
D. because the earth rotates and it is hotter at the equator than elsewhere.
E. only because the "horse latitudes" are regions of low pressure while there is a region of high pressure along the equator.

Items 3 - 4. Weather in the conventional manner of thinking is rather closely associated with certain topographical features. We might imagine certain geologic changes and attempts to correlate them with local weather conditions.

3. (3.00) If Lake Michigan were to completely vanish, winters in Chicago would

A. remain unchanged. **B.** become colder.
C. become more mild. **D.** disappear completely.

4. (3.00) If the Lake were to vanish, summers in Chicago would

A. remain unchanged. **B.** become hotter.
C. become more mild. **D.** disappear completely.

5. (1.10) The movement of the atmosphere in the center of a *low* pressure area is

A. clockwise and downward
B. clockwise and upward.
C. counter-clockwise and upward.
D. counter-clockwise and downward.
E. none of the above.

6. (1.10) The pattern of circulation around a low pressure area in the northern hemisphere is

A. counter-clockwise and away from the center.
B. clockwise and away from the center.
C. counter-clockwise and toward the center.
D. clockwise and toward the center.
E. none of these.

7. (1.10) All of the following concerning the stratosphere are correct *except*

A. the temperature is approximately the same from season to season.
B. it contains little or no moisture.
C. there is little air turbulence and the wind is constant in direction.
D. it is colder and higher over the polar regions than over the equatorial region.
E. it is very widespread, but has a total weight of only about one-fourth that of the troposphere.

8. (1.10) The constituent of the atmosphere that can best be correlated with weather is

A. oxygen. **B.** carbon dioxide. **C.** nitrogen.
D. water vapor. **E.** dust.

9. (1.10) In meteorological science, the most important constituent of the atmosphere is

A. carbon dioxide. **B.** nitrogen. **C.** water vapor.
D. oxygen. **E.** none of the above.

10. (1.10) The most important over-all feature in weather forecasting is the

A. prevailing wind. **B.** air mass. **C.** rainfall.
D. cyclone. **E.** none of these.

11. (1.10) The center of cyclonic air movements usually bring inclement weather because

A. the air in such movements is descending from the upper atmosphere.
B. cyclonic air movements develop only in moist air masses.
C. cyclonic air movements develop only along cold fronts.
D. the rising air currents result in precipitation.
E. the air circulation is counter-clockwise in direction.

12. (1.10) An air mass is considered unstable if

A. it is warmer than the land surface over which it is moving.
B. warm, light layers of air overlie cold, dense layers of air.
C. cold, dense layers of air overlie warm, light layers of air.
D. the relative humidity is very high.
E. the temperature is below 32°F.

13. (1.10) An air mass consisting of dry air is stable if

A. the air is colder than the land surface over which it is moving.
B. relatively colder layers are superimposed on warmer layers.
C. air layers of greater density overlie layers of less density.
D. light warm layers are superimposed on relatively heavy cold layers.
E. the air is warmer than the land surface over which it is moving.

Items 14 - 18. Select the term from the key which best corresponds to the item.

KEY

A. Altostratus. **B.** Cirrus. **C.** Nimbus.
D. Smog. **E.** Fair weather cumulus.

14. (1.10) Clouds neither very high nor very low.

15. Usually associated with rain.
(1.10)

16. Ice particles at elevations about 20,000 feet.
(1.10)

17. Usually associated with clear weather following the passage of a cold front.
(1.10)

18. A thick dark fog at ground level.
(1.10)

Items 19 - 21. Select from the key the term which best corresponds to the item.

KEY

A. Continental Polar. **B.** Continental Tropic.
C. Maritime Polar. **D.** Maritime Tropic.
E. None of these.

19. The hot and dry air mass coming to Chicago during the summer from the Southwest.
(1.10)

20. The air mass arriving at Chicago during the winter from over northern Canada.
(1.10)

21. The air mass arriving over Chicago during the summer having a relative humidity close to 100.
(1.10)

22. The prevailing wind is from the northeast in the
(1.10)

A. doldrums. **B.** horse latitudes.
C. prevailing westerlies belt. **D.** trade winds.
E. polar belt.

23. A mass of moist air coming from the northwest and rotating counterclockwise about its center is a
(1.10)

A. high. **B.** tornado. **C.** cyclone. **D.** zephyr.
E. drift.

24. Within a period of 30 minutes the temperature dropped 15°; the wind direction changed from southwest to northwest, and the relative humidity decreased sharply. One would expect the pressure to
(2.40)

A. rise rapidly. **B.** rise slowly.
C. remain constant. **D.** fall rapidly.
E. fall slowly.

25. With rising temperature the ability of the air to contain water vapor will
(1.10)

A. increase. **B.** decrease. **C.** remain constant.
D. fluctuate.

26. The earth's atmosphere extends to at least 40 miles above its surface. Which of the following offers the best support for this statement?
(1.10)

A. The atmosphere must measure at least 10% of the earth's diameter.
B. Molecules of air do not escape from the earth's attraction at altitudes of less than 40 miles.
C. The density of the earth's atmosphere decreases with altitude.
D. Hydrogen and helium are light enough to rise at least 10 miles.
E. Meteors usually become visible at heights greater than 40 miles.

27. Precipitation occurs as warm air rises over the cold air "wedge" because
(1.10)

A. warm air cannot hold as much water vapor as cold air can.
B. the rising air cools and loses some of its capacity for holding moisture.
C. warm air takes no more water vapor from the cold air than it is able to hold.
D. warm air expands as it rises and loses all its water vapor.
E. water vapor in the air changes into droplets when it encounters the warm air.

28. Which of the following best accounts for the fact that warm air rises above cold air in the "front"?
(1.10)

A. Warm air contains less moisture and therefore is lighter.
B. Warm air has a higher temperature.
C. Warm air moves faster.
D. Warm air is less dense than cold air.
E. Warm air contains a higher percentage of helium.

29. Which of the following necessarily results in a decrease in the relative humidity of an air mass?
(1.22a)

A. Cooling off the air mass.
B. Considerable warming of a moist air mass.
C. Rise of a dry air mass to a high altitude.
D. An air mass encountering a cold front.
E. Heavy precipitation.

30. To say that the relative humidity on a given day is 70% means
(2.10)

A. the water vapor in the air constitutes 70% of the air.
B. the air holds 70% of the total amount of water vapor which it is capable of holding at that temperature.
C. the air contains 70 parts of water to 100 parts of dry air.
D. the water vapor in the air constitutes 30% of the air.
E. the air contains the same amount of water that it would contain at 70°F.

31. The observation has been made that there are no clouds in the stratosphere. This atmospheric zone is cloudless because
(1.10)

A. the sun's radiation keeps it too warm to allow condensation.
B. water vapor will not condense in this thin air.
C. rising air currents carrying water vapor do not penetrate this zone.
D. low temperature in the stratosphere prevents the formation of clouds.
E. there are no dust particles in this zone.

32. The chief difficulty encountered in the study of weather is the
(1.10)

A. immense quantity of air in an air mass.
B. extreme temperature range involved.
C. coordination of data from an extremely large number of reporting stations.
D. ever changing composition of the atmosphere.
E. isolation of a problem.

33. The centers of anticyclonic air movements usually bring fair weather because
(1.10)

A. a clockwise whirl in the northern hemisphere will not develop clouds.
B. anticyclonic air movements develop only in dry air masses.
C. the air in such movements, descending from the upper atmosphere, has low humidity.
D. anticyclonic air movements develop along cold fronts.
E. the atmosphere is very stable.

34. On the passage of a cold front, one may usually expect
(1.10)

A. 24 to 48 hours of thundershowers.
B. the barometer to fall for approximately 24 hours.
C. snow.
D. the weather to get colder.
E. a period of approximately one or two days of more or less steady rainfall.

35. The chief importance of dew point is that it
(1.10)

A. tells whether warm weather may be expected.
B. tells whether cold weather may be expected.
C. assists in forecasting precipitation.
D. indicates air pressure changes.
E. indicates temperature changes.

36. Meteorology includes the study of all of the following
(1.10) *except*

A. the gas laws. **B.** fluid dynamics. **C.** meteors.
D. thermodynamics. **E.** the weather.

37. All of the following concerning the stratosphere are
(1.10) correct *except*

A. the temperature is approximately the same from season to season.
B. it contains little or no moisture.
C. there is little air turbulence and the wind is constant in direction.
D. it is colder and higher over the polar regions than over the equatorial region.
E. it is very widespread, but has a total weight of only about one-fourth that of the troposphere.

38. Accurate forecasting of weather conditions for several
(1.10) days in advance is most dependent upon a detailed knowledge of

A. the probable appearance of sunspots.
B. the composition and movement of air masses.
C. fluctuations in magnetic intensity.
D. the phases of the moon.
E. the chemical composition of the atmosphere.

39. A sudden fall in the barometer reading would usually
(1.10) indicate

A. the passing of a storm center.
B. the approach of a cyclonic disturbance.
C. a period of settled fair weather.
D. a rapidly falling temperature.
E. the approach of clear, cold weather.

40. The type of cloud most often associated with stable
(1.10) stratification of an air mass is

A. cirrus. **B.** nimbus. **C.** stratus.
D. cumulus. **E.** none of these.

41. Bodies of water help to moderate the climate because
(1.10)

A. heat is given off when water evaporates.
B. the specific heat of water is relatively large.
C. the warmest water is always found at the surface.
D. water is a good conductor of heat.
E. water has a very high dielectric constant.

42. Wind velocities are apt to be high when
(1.10)

A. the sky is overcast.
B. the region is surrounded by a high pressure area.
C. the isotherms are far apart.
D. the isobars are close together.
E. fog is present in the region.

43. If the earth ceased to rotate,
(1.10)

A. an object would weigh more at the poles.
B. the period of revolution of the moon around the earth would gradually but noticeably decrease.
C. the wind systems of the earth would be distinctly modified.
D. the year could no longer be used as a measure of time.
E. the use of solar but not sidereal time would have to be discontinued.

44. A fog differs from a cloud largely in that a fog is
(1.10)

A. much denser. **B.** closer to the ground.
C. of different origin. **D.** caused by man's activities.
E. not present on a sunny day.

45. In the United States the air masses and cyclones move
(1.10) generally

A. eastward. **B.** westward. **C.** northward.
D. southward. **E.** in no particular direction.

46. A cold front
(1.10)

A. has an associated cloud system that generally covers more surface area than the cloud system associated with a warm front.
B. is generally marked by less turbulence than a warm front.
C. is made up of a layer of cold air over warmer air.
D. occurs when cold air approaches warmer air.
E. exists only in the northern latitudes.

47. The northeast trades are
(1.10)

A. regions of recurrent cyclonic storms.
B. characterized by prevailing easterly winds.
C. north of Lansing, Michigan.
D. are centered at the equator.
E. migrate north and south of the equator.

48. Normally it is impossible to interpret directly from a
(1.10) weather map the

A. types of clouds. **B.** barometric pressure.
C. wind velocity. **D.** the isotherms.
E. the sky cover.

49. Sharp, sudden decrease in barometric readings can
(1.10) indicate

A. all of the following four conditions.
B. the approach of a cyclonic disturbance.
C. a period of settled fair weather.
D. a rapidly falling temperature.
E. the approach of clear, cold weather.

50. The movement of the atmosphere in the center of a
(1.10) high pressure area is

A. downward.
B. counter-clockwise and toward the center.
C. counter-clockwise and away from the center.
D. clockwise and toward the center.
E. counter-clockwise and upward.

51. The chief importance of dew point to airmen is that it
(1.10)

A. gives warning of approaching snow storms.
B. tells whether cold weather may be expected.
C. assists in forecasting fog.
D. indicates air pressure changes.
E. aids in indicating high winds.

52. When the dew point is 1 degree below the air temperature, the most probable prediction for an airman would be that
(1.10)

A. a fog may be encountered.
B. the barometer will rise rapidly.
C. strong winds are certain.
D. the weather will be clear.
E. there is no danger of icing conditions.

53. A warm front is a
(1.10)

A. summer heat wave.
B. low pressure area with temperatures above normal.
C. mass of warm air displacing cold air.
D. maritime tropical air mass.
E. rapidly rising air column.

54. In general, if the earth were not rotating, the air over East Lansing, Michigan, would move
(1.10)

A. south. **B.** west. **C.** east. **D.** north.
E. not at all.

Item 55 deleted.

56. A cold front
(1.10)

A. has an associated cloud system that generally covers more surface area than the cloud system of a warm front.
B. is generally less turbulent than a warm front.
C. is made up of a layer of cold air over a layer of warm air.
D. is always a boundary between two dissimilar air masses.
E. is found only in the northern hemisphere.

57. Which of the following terms does not share in the relationship of the other four?
(1.10)

A. Alto-annular. **B.** Cirrus. **C.** Stratus.
D. Cumulus. **E.** Nimbus.

Items 58 - 63 refer to meteorological phenomena. For each item select from the key the most appropriate response.

KEY

A. The center of a low pressure area.
B. An anticyclone. **C.** A cold front.
D. Winds circulating counterclockwise toward a center of pressure.
E. A warm air mass overtaking a cold air mass.

58. A relatively narrow transition zone often accompanied by violent storms.
(1.10)

59. Characterized by descending air.
(1.10)

60. Most apt to be associated with clear cool weather.
(1.10)

61. Sometimes called a cyclone.
(1.10)

62. Most frequently shows sudden or abrupt changes in the direction of the isobars.
(1.10)

63. The approach of which is revealed by cirrus clouds.
(1.10)

64. When a large lake freezes over
(1.10)

A. 80 calories of heat are absorbed by every gram of water that freezes.
B. the presence of so much ice makes the water of the lake colder.
C. the air above it is warmed.
D. the air above it is cooled.
E. there is no effect on the surrounding environment.

65. In a cold front
(1.10)

A. no warm air is present.
B. storms are less severe than in a warm front.
C. many more cloud forms are seen than in a warm front.
D. precipitation is always sleet or snow.
E. a cold air mass displaces a warm air mass.

66. Clouds form when
(1.10)

A. there is an increase in the temperature of the air.
B. the center of an air mass arrives at a given area.
C. wind velocities reach a certain critical value.
D. moist air rises to higher elevations.
E. the air has absorbed a certain amount of heat from the sun.

67. Normal atmospheric pressure at sea level corresponds to a column of mercury of the following height:
(1.10)

A. 30 inches. **B.** 28 inches. **C.** 32 inches.
D. 34 inches. **E.** 36 inches.

Items 68 - 81. After the number on the answer sheet which corresponds to that of each of the following items, black space

A. if the item is truer for warm front.
B. if the item is truer for cold front.
C. if the item is equally true of both warm and cold fronts.

68. It contains air usually at a higher pressure.
(1.10)

69. It contains air with more moisture.
(1.10)

70. It may enter from Canada.
(1.10)

71. It may leave by way of New England.
(1.10)

72. Its cross-section shows a gradual slope.
(1.10)

73. It is preceded by rain of longer duration.
(1.10)

74. It is succeeded by brisk invigorating weather.
(1.10)

75. It can be modified by the land over which it passes.
(1.10)

76. Its passage is often characterized by thundershowers.
(1.10)

77. (1.10) It generally moves in an easterly direction.

78. (1.10) It is present only when there is contact of air of different temperature.

79. (1.10) Its passage is followed by humid days.

80. (1.10) It is preceded many miles by cloud formations of horizontal development.

81. (1.10) It may move from 500 to 700 miles per day.

Items 82 - 88. After each item number on the answer sheet, blacken space

A. if the statement is true of a high pressure area.
B. if the statement is true of a low pressure area.
C. if the statement is true of both a high pressure and low pressure area.
D. if the statement is true for neither a high pressure nor a low pressure area.

82. (1.10) In the Northern Hemisphere, the wind in such an area is moving in a counter-clockwise direction.

83. (1.10) An area in which the air is rising as one goes toward the center.

84. (1.10) When the air in such an area has come down from the north, we experience cool and dry weather.

85. (1.10) All regions covered by such areas will have the wind blowing from the same direction.

86. (1.10) The general direction in which the air in such an area moves is due to the rotation of the earth.

87. (1.10) Such an area contains no air currents.

88. (1.10) Such an area is more often than not associated with cloudy weather and rain.

Items 89 - 100. After the number on the answer sheet which corresponds to that of each of the following paired items, blacken space

A. if the item at the left is of greater magnitude than the item at the right.
B. if the item at the right is of greater magnitude than the item at the left.
C. if the two items are of the same magnitude, or it cannot be said that one is greater than the other.

89. (1.10)	Extent to which the trade winds blow toward the east.	....	Extent to which the trade winds blow toward the west.
90. (1.10)	Extent to which the "horse latitudes" are belts of high pressure.	....	Extent to which the "horse latitudes" are belts of low pressure.
91. (1.10)	Extent to which dry weather is characteristic of the equatorial zone.	....	Extent to which rainy weather is characteristic of the equatorial zone.
92. (1.10)	Tendency of winds in the zone between 30° N. and 60° N. to blow from the west.	....	Tendency of winds in the zone between 30° S. and 60° S. to blow from the west.
93. (1.10)	Usual height of air masses moving from the equator toward the poles.	....	Usual height of air masses moving from the poles toward the equator.
94. (1.10)	Extent to which during summers in the temperate zones, high pressures and low temperatures characterize large land areas.	....	Extent to which during summers in the temperate zones, low pressures and high temperatures characterize large land areas.
95. (1.10)	The height of the mercury in a barometer at the foot of a mountain.	....	The height of the mercury in the barometer when carried to the top of the mountain.
96. (1.10)	Extent to which one can anticipate steady rainfall given the approach of a cold front.	....	Extent to which one can anticipate steady rainfall given the approach of a warm front.
97. (1.10)	Tendency of air at the pole to flow downward toward the earth.	....	Tendency of air in the "horse latitudes" to flow downward toward the earth.
98. (1.10)	Expectation of thunderstorms given the approach of a cold front.	....	Expectation of thunderstorms given the approach of a warm front.
99. (1.10)	Steepness of the slope of a warm front.	....	Steepness of the slope of a cold front.
100. (1.10)	Extent to which their feather-like clouds, very high in the sky, indicate the approach of a cold front.	....	Extent to which the same clouds indicate the approach of a warm front.

Items 101 - 107 deleted.

108. (1.10) Kinks (sudden changes in curvature) may be expected in the isobars on a weather map

A. at high pressure areas. **B.** in summer only.
C. at a front. **D.** only in a thunderstorm.
E. only over mountains.

109. (1.10) Air will always tend to move outward and away from the center of a

A. cyclone. **B.** tornado. **C.** cloud.
D. high pressure area. **E.** low pressure area.

110. (1.10) On the surface of the earth as a whole the wind blows in general

A. from low pressure areas to high pressure areas.
B. toward the west. **C.** toward the east.
D. toward the north.
E. from high pressure areas to low pressure areas.

111. (1.10) Lines on a weather map which identify high and low pressure areas are

A. isomers. **B.** isoclinic. **C.** isotherms.
D. isobars. **E.** isogonic.

112. Normal atmospheric pressure may be expressed in all of
(1.10) the following ways *except*

A. 1,013,000 dynes/cm.^{2}. **B.** 76 cm. of mercury.
C. 30 in. of mercury. **D.** 1033.6 grams/cm.^{2}.
E. 62.4 lbs./in.^{2}.

113. Which one of these generally covers the greatest area?
(1.10)

A. A cold front. **B.** A hurricane.
C. An air mass. **D.** A high pressure area.
E. A cyclone.

114. Which one of these clouds is a common thunder cloud?
(1.10)

A. Cumulus humilus. **B.** Stratus. **C.** Cirrus.
D. Nimbo stratus. **E.** Cumulo nimbus.

115. An isobar is
(1.10)

A. a unit of pressure. **B.** a type of barometer.
C. a unit of wind velocity.
D. a line connecting points having the same temperature.
E. a line connecting points having the same pressure.

116. A millibar is a unit of
(1.10)

A. work. **B.** force. **C.** energy. **D.** distance.
E. pressure.

117. A device for measuring humidity is a/an
(1.10)

A. hydrometer. **B.** anemometer. **C.** seismograph.
D. hygrometer. **E.** thermostat.

118. Dew point is
(1.10)

A. the temperature at which condensation occurs in a given atmospheric condition.
B. the temperature at which moisture in the air always freezes.
C. the ratio of relative humidity to the water content of the air.
D. the number of grams of water vapor per cubic meter.
E. the water vapor pressure of the atmosphere.

119. The doldrums are sometimes referred to as the
(1.10)

A. horse latitudes.
B. signposts of the Tropic of Cancer.
C. permanent lows. **D.** permanent highs.
E. anticyclones.

120. The doldrums are
(1.10)

A. regions where convergent air currents are rising.
B. sometimes referred to as the horse latitudes.
C. located at the Tropic of Cancer.
D. regions of high pressure.
E. anticyclones with clockwise air currents.

121. The humidity of the atmosphere
(1.10)

A. is the pressure of the water vapor in it, divided by the vapor pressure of water, at that temperature.
B. is never less than 100%.
C. is frequently more than 100%.
D. varies with the amount of CO_2 in the air.
E. in the winter is usually high, in the case of warm indoor air.

122. Glacial climates are best explained by the
(1.10)

A. decrease in CO_2 in the atmosphere.
B. elevation of the continents.
C. solar-topographic hypothesis.
D. increase in snowfall of the Pleistocene.
E. dry character of the Pleistocene.

123. Why is the relative humidity of air in dwelling houses
(1.10) usually too low during winter?

A. The air loses its small amount of moisture as it circulates through the furnace.
B. Stoves absorb moisture out of the air.
C. Cold air contains little moisture and heat increases the vapor-holding capacity of the air.
D. The windows are closed during the winter.

124. Which one of the following statements is correct?
(1.10)

A. A high-pressure cell lies over central Asia in July.
B. A high-pressure cell lies over the North Pacific near the Aleutian Islands throughout the entire year.
C. A low-pressure cell lies over central Australia in July.
D. A low-pressure cell lies over the South Pacific at about 30° S. during the entire year.
E. A high-pressure cell lies over central U. S. A. in January.

125. What type of air mass might usually have northern
(1.10) Canada as a summer source region?

A. cT. **B.** mP. **C.** mA. **D.** mT. **E.** cP.

126. The belts of doldrums, horse latitudes, and polar fronts
(1.22a) regularly move north and south because of

A. rotation of the earth on its axis.
B. revolution of the earth in its orbit.
C. seasonal changes in atmospheric conditions.
D. unequal distribution of solar radiation.
E. transfer of great quantities of heat in the primary circulation pattern.

127. If the temperature at a certain time of day is 85°F. and
(1.22a) the relative humidity is 94%,

A. an increase in temperature of 15° will cause rain.
B. any increase in temperature will be accompanied by an increase in relative humidity.
C. it will rain if the temperature is decreased sufficiently.
D. it is raining.
E. relative humidity will have to decrease before rain will fall.

128. If an air mass expands adiabatically its temperature will
(1.22a)

A. fall because energy is needed to push back the air boundaries.
B. fall because fewer collisions occur between molecules of air.
C. fall because of large heat losses to the surrounding air.
D. rise because heat causes expansion of most substances.
E. rise because air in motion produces heat by friction.

129. The statement which is *false* is that
(1.22a)

- **A.** all points along an isobar are of equal barometric pressure.
- **B.** an east wind blows *from* the *east* to the *west.*
- **C.** normally a high pressure area is characterized by descending air currents.
- **D.** the horse latitudes are high pressure areas.
- **E.** air cools even more rapidly on expanding if the dew point is reached on cooling and moisture in the air condenses.

Item 130 deleted.

131. Which one of the following is *correct* concerning atmospheric phenomena?
(1.22a)

- **A.** The dew point is always equal to or greater than the air temperature.
- **B.** Lowering the temperature of the air without any other changes increases the relative humidity.
- **C.** The differences between the readings of a "wet" bulb and a "dry" bulb thermometer indicate the air pressure.
- **D.** The hydrometer is used to measure the actual amount of water vapor in the air.
- **E.** Evaporation *cannot* take place below the freezing temperature of water.

132. With a sudden fall in a barometer reading one would expect
(1.22a)

- **A.** winds circulating counterclockwise over the region.
- **B.** a decided drop in temperature.
- **C.** the approach of an anticyclone.
- **D.** cirrus cloud formations.
- **E.** descending air currents.

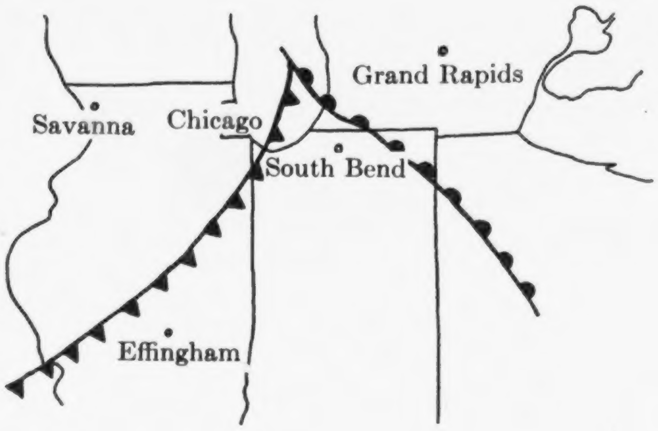
133. Even though heated air rises, the temperature in the upper atmosphere is less than in the lower atmosphere because
(1.30)

- **A.** heated air cools by radiation.
- **B.** rising air cools by contact with cold air.
- **C.** the intensity of heat is reduced by increase in volume.
- **D.** adiabatic heating of ascending air absorbs heat.
- **E.** excess heat is transformed into molecular energy.

134. St. Louis and Chicago have about the same average minimum low temperatures during the winter even though Chicago is about 300 miles farther north. One explanation is that
(1.31)

- **A.** St. Louis is closer to sea-level.
- **B.** 300 miles is insufficient to note changes in average minimum low temperatures.
- **C.** Lake Michigan loses heat slowly.
- **D.** river towns have mild winters.

Items 135 - 141. In the next column is a weather map of conditions in the Chicago area during winter. The items below the diagram refer to weather conditions at the various cities located on the map. After each item number on the answer sheet, blacken the *one* lettered space which designates the city listed in the key to which the item correctly refers.



KEY

A. Savanna, Ill. **B.** Chicago, Ill.
C. Effingham, Ill. **D.** South Bend, Ind.
E. Grand Rapids, Mich.

135. Overcast skies of cumulo-nimbus clouds. Rapidly falling barometer. Southwesterly winds with heavy gusts. Temperature, 48°F.
(2.10)

136. Clear skies. High barometric reading. Light and variable winds. Temperature, 10°F.
(2.10)

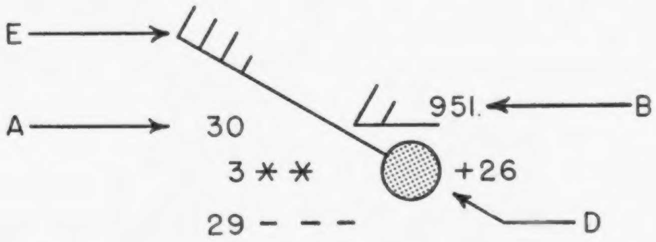
137. Overcast skies of cumulus clouds. Heavy snow flurries. Rapidly rising barometer. Northwesterly winds. Temperature, 25°F.
(2.10)

138. Partly cloudy. Low, steady barometric reading. Southerly winds. Temperature, 44°F.
(2.10)

139 Overcast skies of alto-stratus clouds, giving way to low stratus clouds. Falling barometer. Southeasterly winds. Temperature, 36°F.
(2.10)

140. Forecast: Snow flurries to cease in three to four hours. Present temperatures will fall to 5-10 degrees above zero. Rapidly clearing skies.
(2.10)

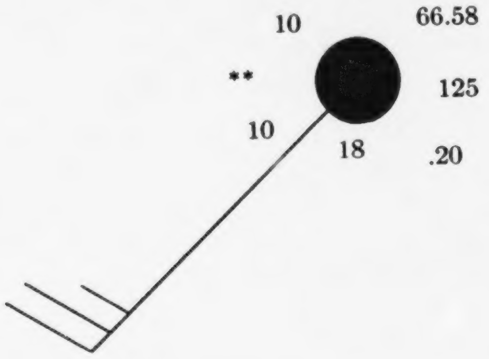
141. Forecast: Rain in two to three hours, lasting 4 to 5 hours. Increasing temperatures following cessation of precipitation. Warm spell to last but a few hours. Heavy rain showers to follow brief warm spell. Rain will turn to sleet and then to snow. Winds will back from present direction to southwest and then to northwest. Heavy snowfall will continue in northwesterly flow of air.
(2.10)



142. The above station model shows that
(2.10)

- **A.** the weather is fair.
- **B.** conditions are getting worse rapidly.
- **C.** the air is very calm.
- **D.** the sky is completely overcast.
- **E.** there is little likelihood of precipitation.

Items 143 - 147 refer to this section of a weather map showing a station model.



For items 143 - 146 select from the key the weather factor shown by the letter in the diagram.

KEY

A. Temperature. **B.** Dew point.
C. Barometric pressure. **D.** Wind velocity.
E. Amount of sky covered by clouds.

143. A. **144.** B. **145.** D. **146.** E.
(2.10) (2.10) (2.10) (2.10)

147. The wind direction in the station model is
(2.10)

A. southeast. **B.** southwest. **C.** northeast.
D. northwest. **E.** not shown.

Items 148 - 152. The diagram below is a vertical cross section of weather conditions existing in the Middle West during the late days of the month of March. The items consist of a list of weather conditions existing at the various cities appearing on the diagram. After the number on the answer sheet which corresponds to that of each of the following items, blacken the one lettered space which designates the city to which the item correctly refers.

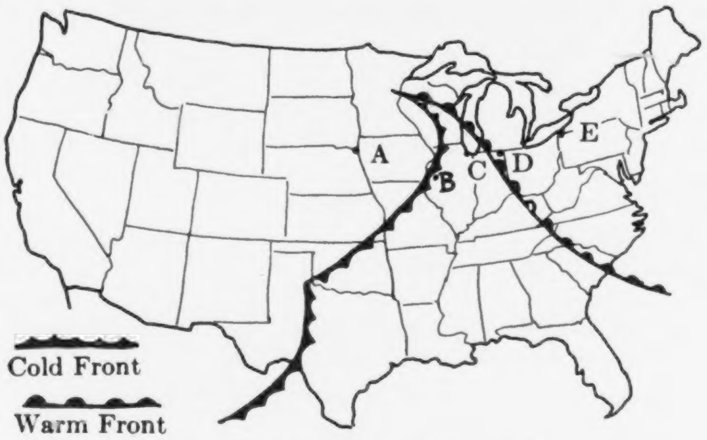
149. Overcast skies of vertically developed clouds with heavy
(2.10) showers. Temperature: 51 degrees. Humidity: 98%. Winds: southwest 25 mph. with heavy gusts. Rapidly falling barometer.

150. High overcast sky of cirrus stratus and alto-stratus
(2.10) clouds. Winds: southeast 10-12 mph. Temperature: 35 degrees. Humidity: 65%. Steady or slightly falling barometer.

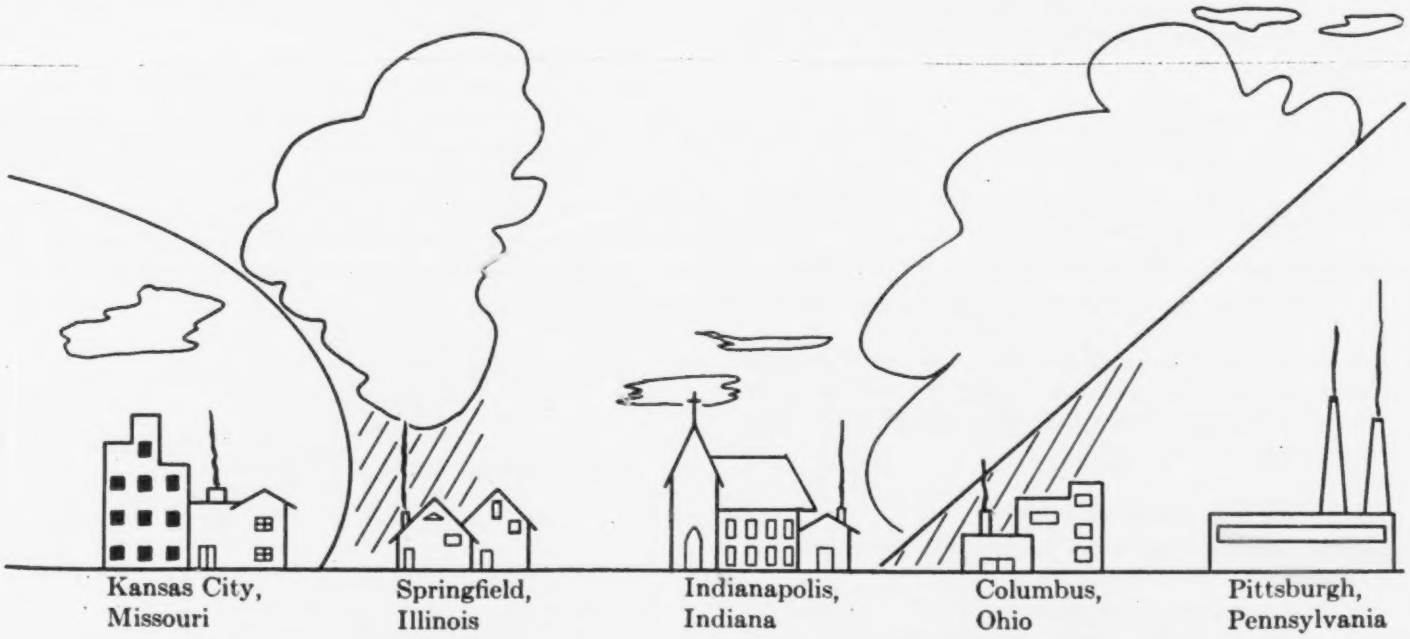
151. Scattered clouds of vertical development. Temperature:
(2.10) 31 degrees. Winds: northwest 25-30 mph. Rapidly rising barometer.

152. Broken sky of stratus clouds with high broken clouds
(2.10) of cirrus. Temperature: 49 degrees. Relative humidity: 85%. Winds: southwest 12-15 mph. Slightly falling barometer.

Items 153 - 157. The diagram below is a weather map of the United States during the late days of March. The items consist of a list of weather conditions existing at the various cities appearing on the map. After each item number on the answer sheet, blacken the *one* lettered space which designates the city to which the item correctly refers.



A. Sioux City, Iowa. **B.** Moline, Ill.
C. Chicago, Ill. **D.** Ft. Wayne, Ind. **E.** Erie, Pa.



A. Kansas City, Mo. **B.** Springfield, Ill.
C. Indianapolis, Ind. **D.** Columbus, Ohio.
E. Pittsburgh, Pa.

148. Overcast sky of stratus clouds with steady rain. Tem-
(2.10) perature: 40 degrees. Humidity: 95%. Winds: south southwest 18-20 mph. Falling barometer.

153. Overcast skies of vertically developed clouds with heavy
(2.10) showers. Temperature: 51°. Humidity: 98%. Winds: southwest 25 mph. with heavy gusts. Rapidly falling barometer.

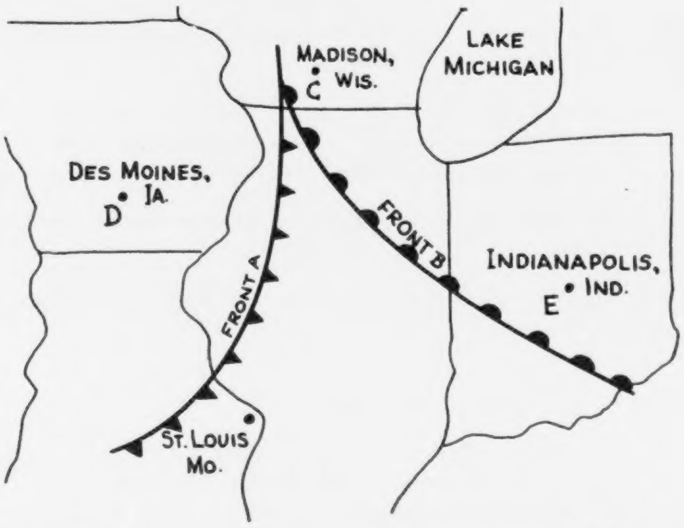
154. Overcast sky of stratus clouds with steady rain. Tem-
(2.10) perature: 40°. Humidity: 95%. Winds: south southwest 18-20 mph. Falling barometer.

155. High overcast sky of cirrus stratus and alto-stratus clouds. Winds: southwest 10-12 mph. Temperature: 39°. Humidity: 65%. Steady or slightly falling barometer.
(2.10)

156. Scattered clouds of vertical development. Temperature: 31°. Winds: northwest 25-30 mph. Rapidly rising barometer.
(2.10)

157. Broken sky of clouds in layers and higher feather-like clouds. Temperature: 49°. Humidity: 85%. Winds: southwest 12-15 mph. Slightly falling barometer.
(2.10)

Items 158 - 165. After each item number on the answer sheet, blacken the *one* lettered space which designates the location on the map to which the item correctly refers. (A and B designate the fronts; C, D, and E the cities.)



158. This is a warm front. **159.** This is a cold front.
(2.10) (2.10)

160. This front moves eastward more rapidly.
(2.10)

161. The town having the lowest temperature.
(2.10)

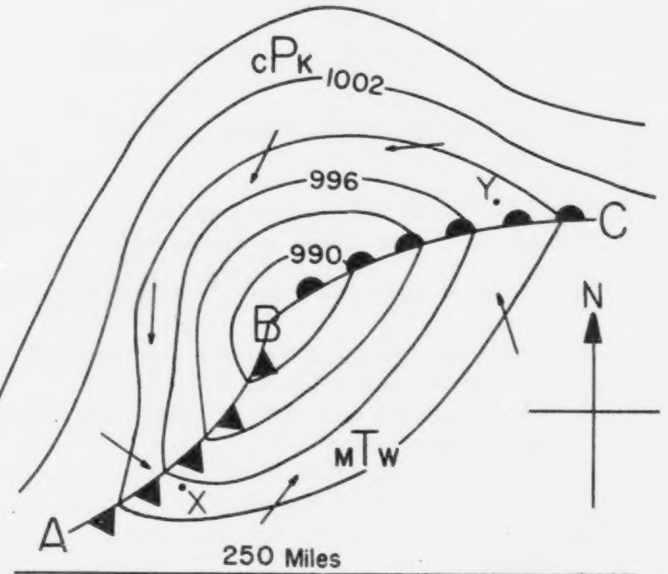
162. A steady rain is probably falling on this town but it does not have the lowest pressure of the towns shown.
(2.10)

163. The town that has the lowest pressure with steady precipitation.
(2.10)

164. The town having the highest pressure.
(2.10)

165. The town most apt to have sunshine.
(2.10)

Items 166 - 179. The following diagram shows a frontal disturbance moving northeastward in this region.



166. The diagram represents
(2.10)

- **A.** a high pressure area.
- **B.** a cyclonic disturbance.
- **C.** an anticyclonic disturbance.
- **D.** the center of an air mass. **E.** none of these.

167. In this diagram, there is shown
(2.10)

- **A.** a warm front. **B.** a cold front.
- **C.** a warm front and a cold front.
- **D.** a stationary front. **E.** an occluded front.

168. The movement of the atmosphere at B is
(2.10)

- **A.** upward. **B.** counter-clockwise.
- **C.** counter-clockwise and upward.
- **D.** counter-clockwise and downward.
- **E.** clockwise and downward.

169. The isobars in this diagram show
(2.10)

- **A.** the distribution of air pressure.
- **B.** the distribution of air temperature.
- **C.** the distribution of relative humidity.
- **D.** the distribution of rainfall.
- **E.** the variation of wind velocity.

170. The air mass to the north and west of ABC is
(2.10)

- **A.** warm and dry. **B.** warm and moist.
- **C.** cold and moist. **D.** cold and dry.
- **E.** very cold and very dry.

171. The air mass to the south and east of ABC is
(2.10)

- **A.** warm and dry. **B.** warm and moist.
- **C.** very warm and very dry.
- **D.** cold and moist. **E.** cold and dry.

172. If this diagram represents conditions during the month of May,–the approach of AB toward X would most probably be forecast by
(2.30)

- **A.** clearing skies.
- **B.** a rapid drop in barometer readings.
- **C.** rapidly increasing temperature.
- **D.** low stratus clouds, followed by continuous precipitation.
- **E.** increasing cloudiness and thunderstorms.

173. If this diagram represents conditions during the month of January, the weather conditions at X after AB has passed by would most likely become
(2.30)

- **A.** cloudy with dense fog.
- **B.** warmer with rain or snow.
- **C.** fair and warmer. **D.** clear and colder.
- **E.** unpredictable.

174. If this diagram represents conditions during the month of January, the barometric pressure at X after AB has passed by most likely would
(2.30)

- **A.** be entirely unpredictable. **B.** remain constant.
- **C.** increase for a short time and then decrease steadily for several hours.
- **D.** decrease steadily for several hours.
- **E.** increase steadily for several hours.

175. If this diagram represents conditions during the month
(2.30) of January, the approach of BC toward Y would most probably be forecast by

- **A.** low stratus clouds followed by continuous precipitation.
- **B.** increasing cloudiness and thunderstorms.
- **C.** rapidly decreasing temperature.
- **D.** rapid rise in barometer readings.
- **E.** clearing skies.

176. If this diagram represents conditions during the month
(2.30) of January, the weather conditions at Y after BC has passed would most likely become

- **A.** clear and colder.
- **B.** colder with rain or snow.
- **C.** warmer with clearing skies.
- **D.** warmer with increasing cloudiness and precipitation.
- **E.** unpredictable.

177. If this diagram represents conditions during the month
(1.10) of May, the relative humidity in the air mass south and east of ABC would most likely be

- **A.** entirely unpredictable.
- **B.** the same as the relative humidity in the air mass north and west of ABC.
- **C.** lower than the relative humidity in the air mass north and west of ABC.
- **D.** higher than the relative humidity in the air mass north and west of ABC.
- **E.** extremely low.

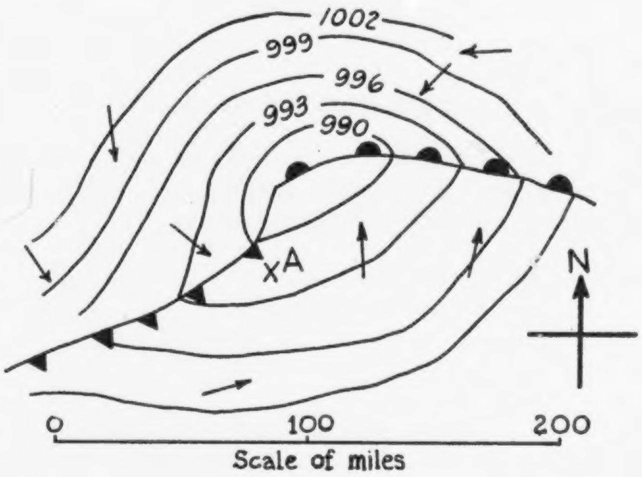
178. The source region of the air mass north and west of
(1.10) ABC could be

- **A.** Southwestern United States.
- **B.** South Pacific Ocean.
- **C.** North Pacific Ocean.
- **D.** North Atlantic Ocean.
- **E.** Northern Canada.

179. The wind directional 50 miles directly north of B would
(2.10) most likely be

- **A.** southwest.
- **B.** northeast.
- **C.** north.
- **D.** south.
- **E.** unpredictable.

Items 180 - 183 refer to the diagram showing a frontal disturbance in this region covering approximately 250 miles and moving in a northeasterly direction.



180. The diagram represents
(2.10)

- **A.** a cyclonic disturbance.
- **B.** the center of an air mass.
- **C.** a high pressure area.
- **D.** an anticyclone.
- **E.** none of these.

181. The front in the diagram is a
(2.10)

- **A.** warm front.
- **B.** cold front.
- **C.** stationary front.
- **D.** combined warm and cold front.
- **E.** superimposed front.

182. As the disturbance moves past point A, an observer
(2.30) would probably note that

- **A.** cold air is displaced by warm air.
- **B.** the barometric pressure remains steady.
- **C.** air temperature remains fairly constant.
- **D.** the wind remains calm and constant in direction.
- **E.** the wind shifts its direction.

183. In December, after the front passed point A, the weather
(2.30) conditions would likely be

- **A.** clearing and colder.
- **B.** warmer with rain.
- **C.** stormy and colder.
- **D.** clearing and warmer.
- **E.** unpredictable without the aid of a station model.

Items 184 - 186 are to be answered in accordance with the following key.

For items 184 - 190 refer to the weather map and barograph trace on page 483.

KEY

- **A.** Warm front.
- **B.** Cold front.
- **C.** Occluded front
- **D.** Stationary front.
- **E.** None of the above.

184. The front from A to B.
(2.10)

185. The front from C to D.
(2.10)

186. The front from E to F.
(2.10)

For items 187 - 189, select from the key the characteristics that describe the air mass given in the item.

KEY

- **A.** Cold and moist.
- **B.** Cold and dry.
- **C.** Warm and dry.
- **D.** Warm and moist.
- **E.** None of the above.

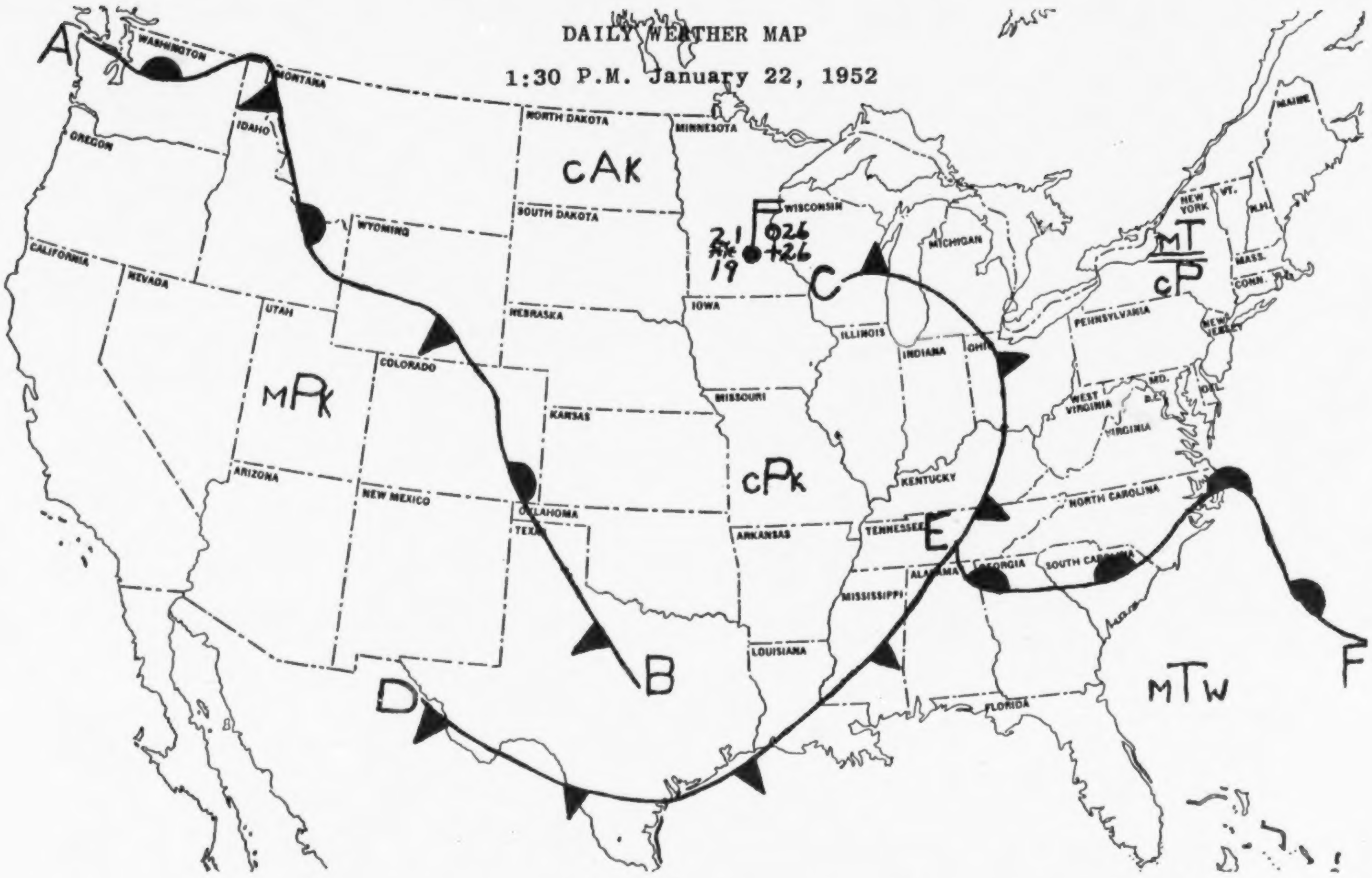
187. The air mass covering the state of Missouri.
(2.10)

188. The air mass covering the state of Nevada.
(2.10)

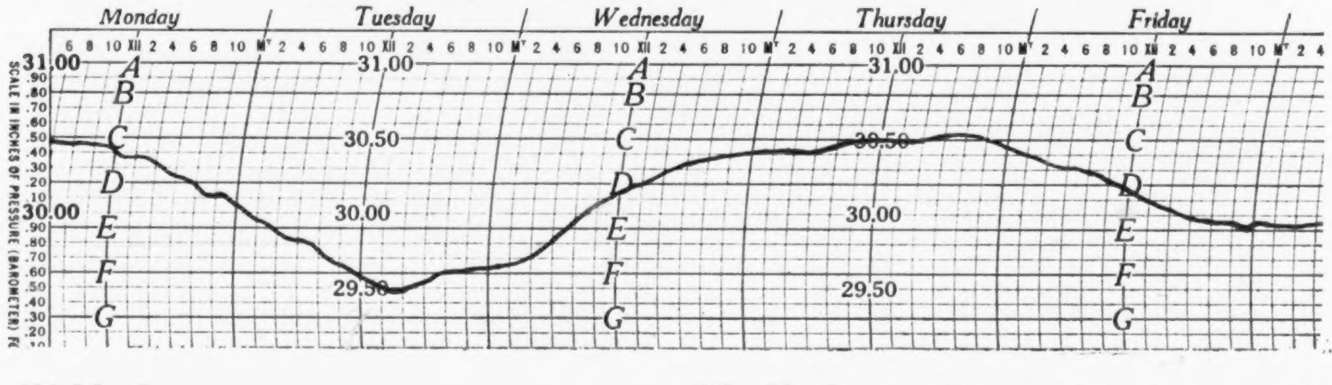
189. The air mass covering the state of Florida.
(2.10)

190. There is a large area of precipitation in northeastern
(2.10) United States. This is due to the fact that

- **A.** a polar air mass is being replaced by an Arctic air mass.
- **B.** a maritime tropical air mass is superimposed on a continental Polar air mass.
- **C.** the northeastern United States is in a region of high barometric pressure.
- **D.** regions of precipitation are larger in the winter than at any other time of the year.
- **E.** the dew point is lower than the temperature in that region.


DAILY WEATHER MAP
1:30 P.M. January 22, 1952
A
B
C
D
E
F
cAk
mPk
cPk
mT/cP
mTw
21
626
19
+26
WASHINGTON
OREGON
CALIFORNIA
NEVADA
IDAHO
MONTANA
UTAH
WYOMING
COLORADO
ARIZONA
NEW MEXICO
NORTH DAKOTA
SOUTH DAKOTA
NEBRASKA
KANSAS
OKLAHOMA
TEXAS
MINNESOTA
IOWA
MISSOURI
ARKANSAS
LOUISIANA
WISCONSIN
ILLINOIS
MICHIGAN
INDIANA
OHIO
KENTUCKY
TENNESSEE
MISSISSIPPI
ALABAMA
GEORGIA
FLORIDA
SOUTH CAROLINA
NORTH CAROLINA
VIRGINIA
WEST VIRGINIA
MD.
D.C.
DEL.
NEW JERSEY
PENNSYLVANIA
NEW YORK
CONN.
MASS.
VT.
N.H.
MAINE

The barograph trace for East Lansing, Michigan for the period beginning Monday, January 21, 1952 is reproduced below.

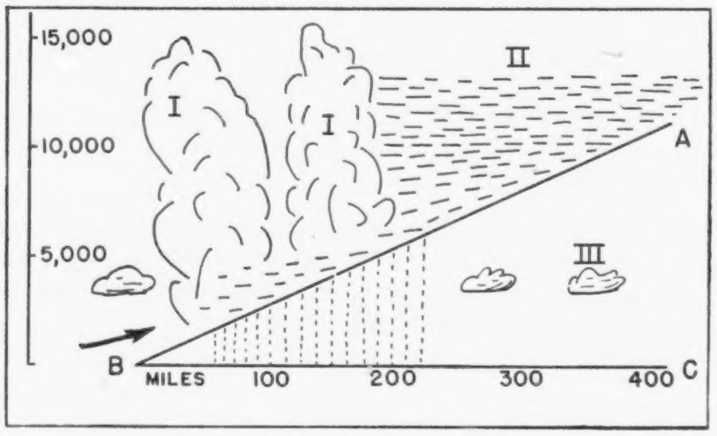


Items 191 - 194 deleted.

195. (1.10) A high pressure area is centered over California. The wind directional 100 miles north of this high pressure center would be expected to be

A. north. **B.** northeast. **C.** northwest. **D.** southwest. **E.** southeast.

Items 196 - 199 refer to the following diagram.


15,000
10,000
5,000
I
I
II
III
A
B
C
MILES
100
200
300
400

196. (2.10) The diagrammatic representation is a cross section of a

A. cold front. **B.** combined warm and cold front.
C. warm front. **D.** occluded front.

197. (2.10) The air mass to the *left* of the line A-B is

A. colder than that on the right.
B. warmer than that on the right.
C. about the same temperature as that on the right.

198. (2.30) In the next 12 hours, the weather at the 300-mile mark will most likely become

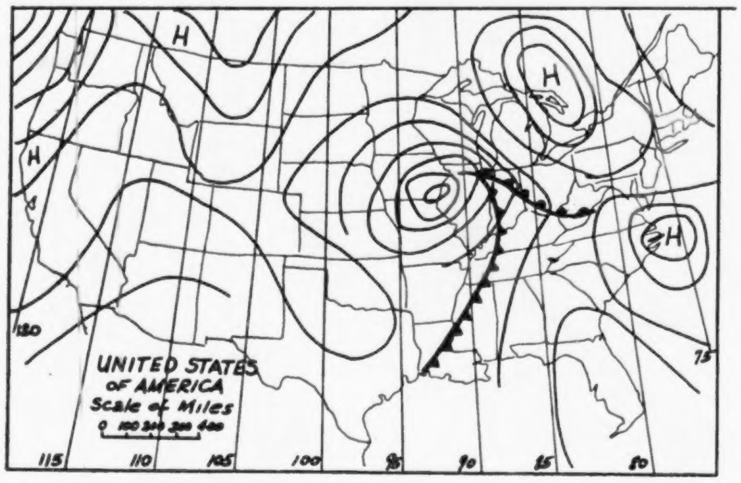
A. clear and warmer. **B.** rainy, then cooler.
C. rainy and warmer. **D.** clear and cooler.
E. clear with occasional thundershowers.

199. (3.00) The bottom of the cloud marked III approximates a plane surface because

A. a temperature inversion is found in the air mass at this height.

B. an isothermal heat exchange between the air in the cloud and the surrounding air begins to operate along this surface.
C. surface winds reach this height, but not above and shear the cloud along a plane surface.
D. the moisture content of the air above this height is less than below.
E. the temperature of the air forming the cloud reaches the dew point first along this surface.

Items 200 - 203 are based on the map found below.



200. (2.30) The low pressure area in the center of the map will probably center in the next 24 hours somewhere near

A. New York City. **B.** Lansing, Michigan.
C. Louisiana. **D.** Northern Minnesota.
E. Colorado.

201. (2.10) The area in which cirrus clouds alone would be found most likely is

A. Missouri. **B.** Northern Indiana. **C.** Louisiana.
D. California. **E.** State of Washington.

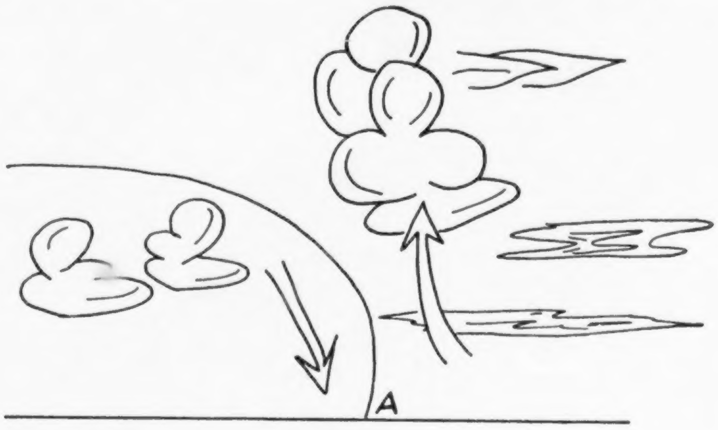
202. (2.10) The pressure (reduced in all cases to sea level)

A. in Missouri is probably greater than 1020 millibars.
B. in California is probably less than 74 cm. of mercury.
C. is greater than 16 lbs. per square inch in the western part of the state of Washington.
D. in North Montana is probably greater than 73 cm. of mercury.
E. on the coast of Virginia is less than 752 mm. of mercury.

203. (1.10) The front extending down the Mississippi Valley is a cold front. The front through Indiana, Illinois, and Kentucky is a warm front. Which statement is true?

A. The area of greatest turbulence (squalls, gusty wind, and thunder storms) is along the warm front.
B. The belt of precipitation is wider along the warm front than the cold front.
C. The air on the east side of the cold front is colder than on the west side.
D. The warm front is probably moving faster than the cold front.
E. The air on the south side of the warm front is cooler than on the north side.

This diagram shows a frontal disturbance moving northeastward in this region. Use it to answer items 204, 205, and 206.



204. (2.10) The front in this diagram is a

A. warm front. **B.** cold front.
C. stationary front.
D. combined warm and cold front.
E. superimposed front.

205. (1.10) In addition to temperature the information most helpful in answering the preceding item involves the

A. ages of the air masses.
B. sources of the air masses.
C. velocities and directions of the air masses.
D. relative humidity of the air masses.
E. position the air masses held during the preceding 24-hour period.

206. (2.30) While the front was passing point A, if it were December, the weather conditions at A would likely be

A. clear. **B.** continuous light snow.
C. intermittent light snow.
D. heavy precipitation as snow if cold enough.
E. entirely unpredictable without the aid of a station model.

207. (2.10) Dry air blows uphill from sea level to an elevation of 7000 feet. If its initial temperature is 88.5°F, its final temperature at 7000 feet will be about

A. 38.5°F. **B.** 31.5°F. **C.** 50°F. **D.** 81.5°F.
E. 127°F.

208. (2.10) Dry air blows downhill from an elevation of 5000 feet to sea level. If its initial temperature is 52.5°F, its final temperature at sea level will probably be about

A. 25°F. **B.** 30°F. **C.** 57.5°F. **D.** 75°F.
E. 80°F.

209. (2.10) The temperature and dew point of an air sample at the earth's surface are 78°F and 69°F, respectively. To about what height, in fact, must the air ascend to produce the cooling needed for the initiation of moisture condensation?

210. (2.10) The ground-level temperature and dew point of a certain air mass are 83.5°F and 70°F, respectively. The temperature at the base of the clouds which are forming, due to convection, would be about

A. 32°F. **B.** 53°F. **C.** 61.5°F. **D.** 67°F.
E. 70°F.

211. (2.20) If, in Lansing, Michigan, wind begins to blow from the east on a clear day and gradually shifts counter-clockwise toward the north, it is probable that a

- **A.** high pressure area is approaching from the east.
- **B.** low pressure area is approaching from the east, the center of which will pass somewhat to the south of Lansing.
- **C.** high pressure area is approaching from the west, the center of which will pass to the south of Lansing.
- **D.** low pressure area is approaching from the west, the center of which will pass somewhat to the north of Lansing.
- **E.** low pressure area is approaching from the west, the center of which will pass somewhat to the south of Lansing.

212. (2.20) On a certain day, it is noticed that black smoke from chimneys drifts to the ground. The best explanation of this observation is that

- **A.** the smoke contained carbon particles.
- **B.** the day was cloudy and rather humid.
- **C.** it was a very windy day.
- **D.** the smoke contained less hydrogen than oxygen.
- **E.** the air was very stable.

213. (2.20) The windward side of a mountain range receives more rainfall than the leeward side of the range because

- **A.** the leeward side is always the warmer side.
- **B.** vegetation is always denser on the windward side and draws the rain.
- **C.** although the winds blow over the range, the rain clouds are too heavy to pass over the summit.
- **D.** air blowing over the summit is forced to rise, thus causing adiabatic cooling and precipitation.
- **E.** none of these.

214. (2.20) "The sun now rose upon the right
Out of the sea came he,
Still hid in mist, and on the left
Went down into the sea.

And the good south wind still blew behind."

The Ancient Mariner was sailing

- **A.** north in the trade winds north of the equator.
- **B.** south in the trades south of the equator.
- **C.** on the equator about the middle of March.
- **D.** south in the trades north of the equator.
- **E.** north in the trades south of the equator.

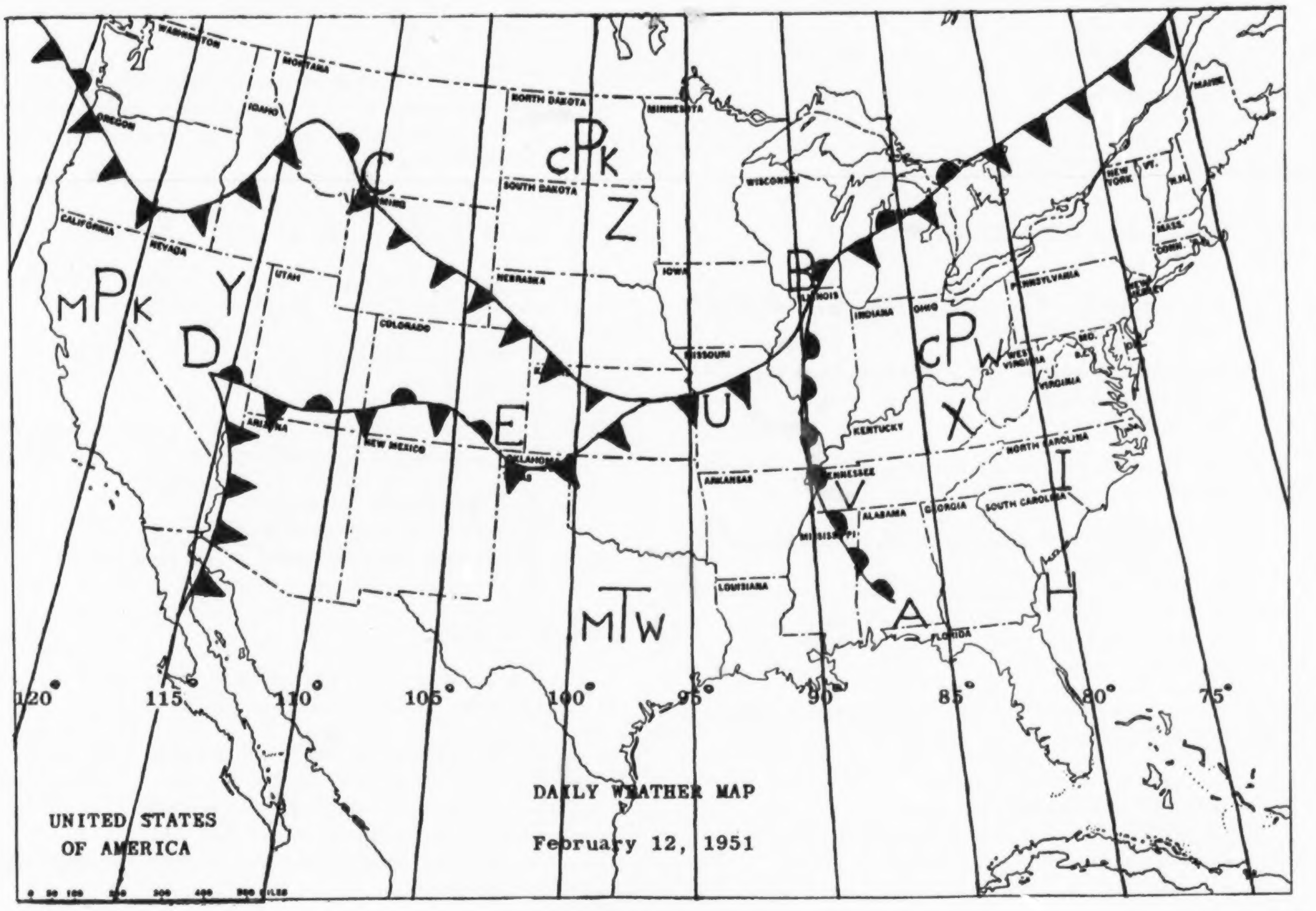
Items 215 - 226 refer to the weather map produced below.

215. (2.30) The center of an extended low pressure area is located approximately 100 miles north of Lansing, Michigan. At the end of the next 12 hour period, the center of this low pressure area can be expected to be

- **A.** north of Lake Ontario.
- **B.** near New York City.
- **C.** near Cleveland, Ohio.
- **D.** near Chicago, Illinois.
- **E.** near Duluth, Minnesota.

216. (1.10) The center of an extended high pressure area is represented by the symbol H. The wind directional I, directly north of H, is most probably

A. northeast. **B.** north. **C.** northwest.
D. southwest. **E.** southeast.


WASHINGTON
MONTANA
NORTH DAKOTA
MINNESOTA
IDAHO
OREGON
C
cPk
SOUTH DAKOTA
WYOMING
Z
WISCONSIN
NEW YORK
VT.
N.H.
MAINE
MASS.
CONN.
CALIFORNIA
NEVADA
UTAH
NEBRASKA
IOWA
ILLINOIS
B
mPk
Y
D
COLORADO
KANSAS
MISSOURI
INDIANA
OHIO
PENNSYLVANIA
cPw
WEST VIRGINIA
MD.
VIRGINIA
ARIZONA
NEW MEXICO
E
OKLAHOMA
U
KENTUCKY
X
TENNESSEE
NORTH CAROLINA
I
ARKANSAS
V
ALABAMA
GEORGIA
SOUTH CAROLINA
MISSISSIPPI
LOUISIANA
mTw
A
H
FLORIDA
120°
115°
110°
105°
100°
95°
90°
85°
80°
75°
UNITED STATES OF AMERICA
DAILY WEATHER MAP
February 12, 1951

217. (2.30) During the next 12 hours, an area of great turbulence (squalls, gusty wind, and thunderstorms) will probably be found in the state of

A. Washington. **B.** South Dakota. **C.** Missouri.
D. Florida. **E.** Massachusetts.

218. (2.30) During the next 12 hours, the most extended area of precipitation will probably be found in the

A. Atlantic coastal region. **B.** Gulf coastal region.
C. Pacific coastal region.
D. northern Great Plains region.
E. Great Lakes region.

Items 219 - 221 are to be answered in accordance with the following key.

KEY

A. Warm front. **B.** Cold front.
C. Occluded front. **D.** Stationary front.
E. None of the above.

219. (2.10) The front from A to B.

220. (2.10) The front from B to C.

221. (2.10) The front from D to E.

For items 222 - 224 select from the key the characteristics that describe the air mass given in the item.

KEY

A. Cold and moist. **B.** Cold and dry.
C. Very cold and very dry.
D. Warm and moist. **E.** Warm and dry.

222. (2.10) The air mass in the vicinity of (X).

223. (2.10) The air mass in the vicinity of (Y).

224. (2.10) The air mass in the vicinity of (Z).

225. (2.30) After the front, AB, passes the point (V), the weather can be expected to become

A. rainy and warmer. **B.** rainy and colder.
C. fair and colder. **D.** fair and warmer.
E. unpredictable.

226. (2.30) After the front BC passes the point (U), the barometric pressure can be expected to

A. be extremely erratic, increasing and decreasing unpredictably.
B. decrease for a few hours and then increase steadily.
C. increase steadily for the next 24 hours.
D. decrease steadily for the next 24 hours.
E. remain constant.

227. (2.30) When the relative humidity is 60% and the air temperature is 75°F., a cooling of a given air mass

A. raises the absolute humidity.
B. lowers the absolute humidity.
C. produces no change in relative humidity.
D. increases the relative humidity.
E. decreases the relative humidity.

For items 228 - 233 mark the statement True or False, then add the letter that best fits the statement.

A. Observation and Terminology.
B. Relativity of Theory and Concept.
C. Cause and Effect.
D. Teleology—Plan and Order.
E. Sampling and Extrapolation.
F. Authority and Authoritarianism.

T F

228. (2.40) __ __ ( ) The weather forecaster learns the conditions of the air as to the various air masses—their direction and rate of movement, temperature, humidity, wind-direction and velocity, pressure and their relations to all other air masses in the area and then makes his forecast.

229. (2.40) __ __ ( ) A meteorological definition of wind is air in horizontal motion.

230. (2.40) __ __ ( ) Cyclones of middle latitudes are areas of low barometric pressure, originating in the westerly winds as stated by meteorologists.

231. (2.40) __ __ ( ) Once air is set in motion it is deflected to the right in the northern hemisphere according to Boyle's Law of Gases.

232. (2.40) __ __ ( ) Several years of dry or comparatively dry weather, as the past year, will be followed by several years of wet weather.

233. (2.40) __ __ ( ) The Northeast Trade winds moved from the Horse Latitude high pressure areas and across the surface and blow into the low pressure area of the Doldrum belt.

234. (3.00) If the humidity in a room is 25 grams of water vapor per cubic meter at 20°C., and the room could be heated to 40° without changing any other factor, the relative humidity would

A. remain the same. **B.** increase.
C. be doubled. **D.** decrease. **E.** be zero.

235. (3.00) In general, if the earth were not rotating, the surface air over East Lansing, Michigan, would move

A. south. **B.** east. **C.** west. **D.** north.
E. not at all.

236. (3.00) If a cloud formation is marked by a rather well-defined bottom parallel to the earth's surface it is an indication of

A. a temperature inversion.
B. isothermal heat exchange.
C. adiabatic heat exchange. **D.** condensation.
E. upper air winds contrary to surface winds.

Item 237 deleted.

238. (3.00) A mass of air has a relative humidity of 50. If that air is warmed and the same mass considered

A. the absolute humidity will increase.
B. the relative humidity will increase.
C. the absolute humidity will decrease.
D. the relative humidity will decrease.
E. both the relative and the absolute humidity will decrease.

239. In the northern hemisphere, if a person faces the wind
(3.00) (that is, the wind blows directly toward his face), the center of a low pressure area could be found

A. at his right. **B.** directly behind him.
C. at his left. **D.** in front of him.
E. at any of the above positions depending upon where the front is located.

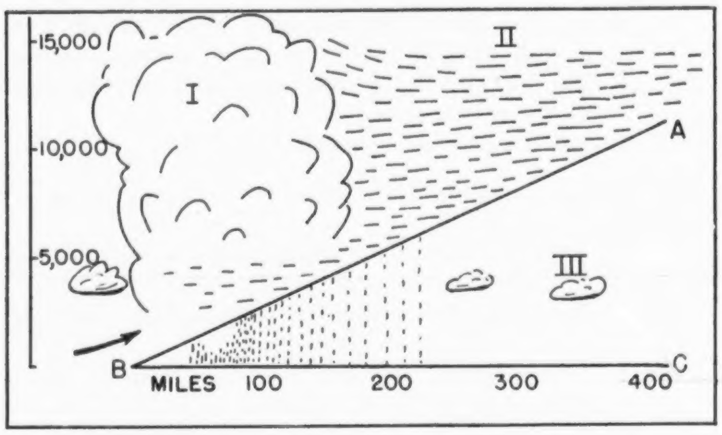
240. If a high pressure area were passing Lansing with its
(3.00) center somewhat north of the city, which one of the following wind directions would be improbable?

A. Wind from the west. **B.** Wind from the east.
C. Wind from the south. **D.** Wind from the north.
E. All of the above could occur before the high pressure area passed.

241. If a barometer and a thermometer fell out of an air-
(3.00) plane at a height of about eight miles over the equatorial region

A. the barometer reading would decrease and the thermometer reading would increase.
B. the readings on both instruments would increase.
C. the readings on both instruments would decrease.
D. the barometer reading would increase and the thermometer reading would decrease.
E. the readings would remain the same on both instruments.

Items 242 - 247 refer to the following diagram.



242. If point A is 12000 feet above the ground, and point C
(3.00) (directly below) is 425 miles from point B, the angle ABC is

A. less than 1 degree. **B.** about 30 degrees.
C. about 45 degrees. **D.** about 60 degrees.
E. about 89 degrees.

243. The cloud marked I is a
(2.10)

A. stratus. **B.** cumulo-nimbus. **C.** cirro-stratus.
D. nimbo-stratus. **E.** cumulus humilis.

244. The precipitation which falls from cloud I is caused
(3.00) largely by

A. a marked rise in the dew point under the cloud along the line A-B.
B. an isothermal heat exchange between the air within the cloud and that outside of the cloud.
C. a cooling of the ground over which the cloud is moving.
D. an adiabatic heat exchange within the cloud.
E. two of the above.

245. The clouds, belonging to the same system, found off
(2.10) the diagram to the right and above the point A would be

A. alto-cumulus. **B.** nimbo stratus. **C.** stratus.
D. cirrus. **E.** strato-cumulus.

246. The air under the cloud at III has its greatest direction
(3.00) of movement

A. upward. **B.** downward.
C. from left to right. **D.** from right to left.

247. In the next 48 hours, the weather at the 300 mile mark
(2.30) can be expected to become

A. clear and warmer. **B.** rainy, then colder.
C. rainy and warmer. **D.** clear and cooler.
E. clear with occasional thundershowers.

Items 248 - 249. One cubic foot of air at 90°F. contains 10.9 grains of water vapor.

248. What is the relative humidity of the air?
(3.00)

A. 33%. **B.** 10.9%. **C.** 14.8%. **D.** 73.6%.
E. 58%.

249. If one cubic foot of the air were cooled to 30°F., about
(3.00) how many grains of water would be condensed?

A. 14.8. **B.** 10.9. **C.** 10. **D.** 9. **E.** 1.9.

Items 250 - 251. An air sample at 55°F. has a relative humidity of 33%.

250. About how many grains of water vapor does each cubic
(3.00) foot of the air contain?

A. 1.6. **B.** 2.4. **C.** 3.2. **D.** 4. **E.** 4.8.

251. About what is the dew point of the air?
(3.00)

A. 15°F. **B.** 20°F. **C.** 25°F. **D.** 30°F.
E. 40°F.

252. A certain sample of air has a dew point of 50°F. What
(3.00) is the relative humidity of the air at 85°F.?

A. 23%. **B.** 32%. **C.** 41%. **D.** 59%. **E.** 85%.

Items 253 - 255. The temperature and dew point of the ground-level air of a certain mass are 97°F. and 70°F., respectively. In the air mass the temperature decrease per 1000-foot height increase is 6°F. from ground level up to a height of 6000 feet, and is 2°F. for heights greater than 6000 feet. A localized upward movement of the ground-level air is started by insolational heating of a small area of the ground.

253. At about what height in feet will moisture condensa-
(3.00) tion begin to occur?

A. 4000. **B.** 5000. **C.** 6000. **D.** 9000.
E. 10,000.

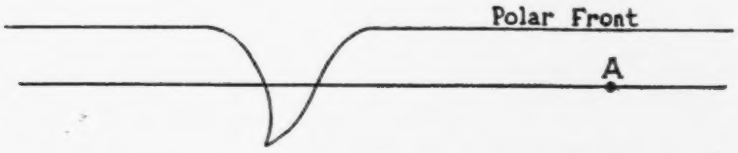
254. About what is the temperature of the rising air when
(3.00) moisture condensation begins?

A. 70°F. **B.** 64°F. **C.** 59°F. **D.** 33°F.
E. 55°F.

255. At about what height in feet will the updraft of rising
(3.00) air cease—that is, what is the upper level of moisture condensation?

A. 4000. **B.** 5000. **C.** 6000. **D.** 9000.
E. 10,000.

256. An observer is located at A, which is directly in the
(3.00) path of a middle-latitude cyclone moving due eastward, as illustrated below.



Which one of the following choices lists the wind directions in the order in which they might typically be observed at A during the passage of the cyclone through A?

(1)	(2)	(3)	(4)	(5)
←	→	←	→	←
↙	↗	↖	↗	↙
↘	↖	↗	↘	↖
↗	↙	↘	↙	↙
↖	↘	↙	↖	↘
←	→	←	→	→

Items 257 - 260. On January 8 the weather map shows a typical cyclone having a low-pressure center over central England with the warm front extending southeastward across the channel through Belgium into northeastern France, and the cold front extending southwestward into the Atlantic.

257. One might reasonably expect that in Ireland the winds
(3.00) would be

A. southwesterly. **B.** northwesterly. **C.** easterly.
D. southerly. **E.** northeasterly.

258. Over the Bay of Biscay the winds would be
(3.00)

A. southwesterly. **B.** northwesterly.
C. northeasterly. **D.** southeasterly. **E.** easterly.

259. Over central Germany the winds would be
(3.00)

A. southwesterly. **B.** northerly. **C.** westerly.
D. northeasterly. **E.** southeasterly.

260. Of the choices listed below, the temperature probably
(3.00) would be highest in

A. Lisbon, Portugal. **B.** Berlin, Germany.
C. Warsaw, Poland. **D.** Dublin, Ireland.
E. Amsterdam, Holland.

Items 261 - 264. On a certain date when the atmospheric pressure was 30 inches, the following observations were made by means of a sling psychrometer:

Reading of dry-bulb thermometer, 60°F.
Reading of wet-bulb thermometer, 45°F.

264. What was the atmospheric temperature?
(2.10)

A. 15°F. **B.** 30°F. **C.** 45°F. **D.** 60°F.
E. 105°F.

265. What was the wet-bulb depression?
(2.10)

A. 15°F. **B.** 30°F. **C.** 25°F. **D.** 45°F.
E. 60°F.

266. What was the relative humidity?
(3.00)

A. 15%. **B.** 26%. **C.** 45%. **D.** 75%. **E.** 60%.

267. Approximately what was the dew point of the air?
(3.00)

A. 15°F. **B.** 24°F. **C.** 32°F. **D.** 45°F.
E. 60°F.

268. In the statement: If an air mass expands adiabatically
(4.20) against external pressure, its temperature will rise because some of the heat energy of the air mass is used in doing work pushing back the air boundaries,

A. the first part of the statement is true, and its truth is supported by the reason given in the statement.
B. the first part is true, but its truth is *not* supported by the reason given.
C. the first part of the statement is false.

269. Which one of the following statements is most plausible?
(6.20)

A. In winter, cP source regions have higher temperatures than mT source regions.
B. In summer, mP source regions have higher temperatures than mT source regions.
C. In winter, mT source regions have lower temperatures than mP source regions.
D. In summer, cT source regions have lower temperatures than cP source regions.
E. In winter, cP source regions have lower temperatures than mP source regions.

10. *Volcanism and Diastrophism*

VOLCANISM AND DIASTROPHISM

1. The immediate cause of anticlines is
(1.10)

A. volanic. **B.** depositional. **C.** metamorphic.
D. erosional. **E.** diastrophic.

2. Cracks or fissures in massive sandstone which extend vertically downward are called
(1.10)

A. joints. **B.** intrusions. **C.** cleavages.
D. schists. **E.** bedding planes.

3. The immediate cause of a normal fault is
(1.10)

A. a lateral compression.
B. the elevation of a crustal block.
C. tensional forces. **D.** igneous intrusion.
E. forcing the hanging wall up over the foot wall.

4. Which of the following statements of possible causes of volcanism receives least support today?
(1.10)

A. The interior of the earth is in the molten condition.
B. The interior of the earth is subjected to enormous pressures.
C. Transformation of radioactive elements within the earth yields heat.
D. Some rocks melt at lower temperatures than others.
E. Liquid rock mixed with gases is lighter than solid rock.

5. In the continent of North America, volcanism as compared with diastrophism
(1.10)

A. ceased to be active hundreds of years earlier.
B. ceased to be active millions of years earlier.
C. has existed with diastrophism up through the current decade.
D. outlived diastrophism hundreds of years.
E. outlived diastrophism millions of years.

Items 6 - 12 refer to the types and properties of waves which are associated with earthquakes. For each item select from the key the most appropriate response.

KEY

A. A statement which applies to more than one type of wave.
B. A statement which applies only to the *primary* waves.
C. A statement which applies only to the *secondary* waves.
D. A statement which applies only to the *long* waves.
E. A statement which is not applicable to any of the three types of waves.

6. Waves which are compressional.
(1.10)

7. Waves which cause the greatest damage in an earthquake.
(1.10)

8. Waves which have great value in predicting the occurrence of future earthquakes.
(1.10)

9. Waves which, if they actually penetrated the inner core of the earth, would furnish proof that the earth is solid throughout.
(1.10)

10. Waves which are shown on a seismogram.
(1.10)

11. Waves which are known as undulatory surface waves.
(1.10)

12. Waves which are used to locate the center of an earthquake disturbance.
(1.10)

13. Joints in the massive sandstone at Grand Ledge, Michigan
(1.10)

A. show that differential movement of crustal blocks has occurred.
B. resulted from faulting.
C. have increased mechanical weathering.
D. exemplify a set rather than a system of joints.
E. have improved the potability of the ground water.

Items 14 - 21 refer to geologic terms and names. Select from the key the immediate cause.

KEY

A. Volcanic. **B.** Erosional. **C.** Depositional.
D. Diastrophic. **E.** Metamorphic.

14. Drowned valleys. (1.10) **15.** Fjords. (1.10)

16. Quartzite. (1.10) **17.** Pyroclastic rock. (1.10)

18. Anticline. (1.10) **19.** Outwash plains. (1.10)

20. River meander. (1.10) **21.** Vesicular basalt. (1.10)

22. At Grand Ledge there is evidence of all of these *except*
(1.10)

A. flood plains. **B.** incipient gullies.
C. cross bedding. **D.** intense folding.
E. stratification.

Items 23 - 28 refer to various theoretical principles and processes in geology. For each item select from the key the most closely related principle.

KEY

A. Volcanism. **B.** Diastrophism. **C.** Isostacy.
D. Two of the above. **E.** None of the above.

23. Fold mountains whose structure consists of synclines and anticlines.
(1.10)

24. The differential erosion of rocks.
(1.10)

25. The Hawaiian Islands.
(1.10)

26. The continual shifting of the lithosphere.
(1.10)

27. The formation of mountains due to faulting.
(1.10)

28. Crustal equilibrium between segments of the lithosphere.
(1.10)

Items 29 - 32 are definitions of geologic terms. Select from the key the correct response.

KEY

A. Sill. **B.** Laccolith. **C.** Batholith. **D.** Dike.
E. None of these.

29. (1.10) Magma which before congealing forms lava flows and pyroclastic deposits.

30. (1.10) A tabular intrusive mass of igneous rock which cuts across other igneous rocks or across bedding of lava or sedimentary formations.

31. (1.10) An intrusive igneous rock mass injected along bedding of sedimentary formations in such a way as to dome the overlying strata.

32. (1.10) A tabular mass of igneous rock that has been intruded laterally between layers of sedimentary rocks, beds of lava, or along the direction of foliation of metamorphic rock.

Items 33 - 37. Select from the key the most closely related word.

KEY

A. Batholith. **B.** Dike. **C.** Sill. **D.** Laccolith.
E. None of the above.

33. (1.10) Tabular body formed by magma forced up through and filling a widened joint.

34. (1.10) Tabular body formed by magma forced between sedimentary rock bedding planes.

35. (1.10) Enormous igneous bodies without known floors forming the cores of mountains.

36. (1.10) Moderate sized dome-shaped bodies with flat floors emplaced between sedimentary rock layers.

37. (1.10) Tabular mass of *ore* more or less sharply delimited from the enclosing rock.

Items 38 - 41 are definitions of geologic terms. Select from the key the term which is defined by the item.

KEY

A. Batholith. **B.** Dike. **C.** Laccolith.
D. Moraine. **E.** None of these.

38. (1.10) Tabular body formed by magma forced up through and filling a widened joint.

39. (1.10) Layered beds and sand bars formed by wave action which produce embayments.

40. (1.10) Amphitheatre-like basins formed by the plucking action of ice.

41. (1.10) Moderate-sized dome-shaped bodies with flat floors emplaced between sedimentary rock layers.

42. (1.10) Igneous intrusions known as sills are

A. fingerlike bodies projecting laterally from a volcanic rock.
B. tabular masses parallel to the bedding structure in the rock.
C. elongated bodies filling widened joints or faults.
D. dome-shaped bodies of limited extent.
E. lava flows which were later covered by other rock.

43. (1.10) A region which is not in the zones of great crustal activity is

A. never mountainous. **B.** marked by many volcanoes.
C. always marked by a rising coastline.
D. disturbed by relatively few earthquakes.

44. (1.10) Metamorphic rock can be formed from magma by which of the following processes?

A. Solidification followed by gradation.
B. Slow cooling beneath the surface.
C. Solidification followed by diastrophism.
D. Solidification followed by volcanism.
E. Rapid cooling above the surface.

45. (1.10) It is found that in the northern portions of the Lake Superior region the sea cliffs seem to be gradually rising while the southern portions are marked with drowned valleys. This can probably be explained by

A. increase in the amount of rainfall.
B. diastrophic movements. **C.** volcanism.
D. a more intense shore erosion in the northern portions.
E. the carrying of the majority of the sediment to the northern portions of the lake.

46. (1.10) One of the results of the Lewis Overthrust, a good example of a thrust fault, was

A. a shortening of the surface.
B. a series of minor earthquakes which account for the present topography in the area.
C. the accumulation of sediment forming several ridges in the area.
D. the formation of a geosyncline on the same side of the fault as the hanging wall.
E. an elongation of the surface.

47. (1.10) The most useful information regarding the composition of the interior of the earth can be derived from earthquakes since

A. different types of earthquake waves travel at different speeds.
B. earthquake waves travel at different rates through different media.
C. earthquakes usually release materials from within the earth which can be studied as to composition.
D. the earth is solid throughout.
E. the amplitude of vibration varies with the type of waves.

48. (1.10) The banks of a meandering stream are V-shaped. This is evidence that this region has been subjected to

A. glaciation.
B. crustal movements increasing the gradient of the stream.
C. forces which increase the lateral erosion of the stream.
D. extensive alluvial deposition.
E. a lowering of the level of the land in the region.

49. (1.10) The disintegration of rock in more or less thin layers, a "shelling off" process, is known as

A. diastrophism. **B.** metamorphism.
C. differential erosion. **D.** exfoliation. **E.** abrasion.

50. (1.10) A river which possesses the following topographic characteristics: V-shaped valleys with steep walls, few short tributaries, high downward gradient, and many rapids and falls, is said to be in the stage of

A. youth. **B.** maturity. **C.** old age.
D. peneplain. **E.** flood.

51. (1.10) When a glaciated valley is submerged by the sea it is called a(n)

A. delta. **B.** alluvial fan. **C.** flood plain.
D. sinkhole. **E.** fiord.

52. A hanging valley
(1.10)

- **A.** results from diastrophism.
- **B.** is produced by a waterfall.
- **C.** is produced by the deposition of rock in a dried out river bed.
- **D.** results when the ice recedes from a tributary glaciated valley which has not been gouged out as deeply as the main glaciated valley.
- **E.** results from the action of sub-surface water.

53. Which of the following factors is of greatest significance in determining the location of an earthquake through the use of seismographs?
(1.10)

- **A.** Primary earthquake waves are longitudinal while the other types are transverse.
- **B.** Primary and secondary waves travel beneath the surface of the earth.
- **C.** The different types of earthquake waves travel at different rates.
- **D.** The primary waves travel through solids and liquids while secondary waves travel only through solids.
- **E.** The core of the earth is much denser than the lithosphere.

54. A broad dark band of igneous rock which cuts across horizontal sedimentary strata stands up in the peak of Grand Teton Mountain, just south of Yellowstone Park. The above mentioned *broad dark igneous band* is a
(1.10)

A. batholith. **B.** laccolith. **C.** dike. **D.** sill.
E. cinder cone.

55. This intrusive mass was formed as a result of
(1.10)

A. diastrophism. **B.** glaciation. **C.** running water.
D. volcanism. **E.** ground water.

56. In Glacier Park, near the tops of the peaks, is a band of dark igneous rock between horizontal layers of white marble, which grade into limestone. This band of dark igneous rock is a
(1.10)

A. batholith. **B.** laccolith. **C.** dike. **D.** sill.
E. volcano.

57. The folding and faulting of strata of sedimentary rock is the result of
(1.10)

A. gradation. **B.** degradation. **C.** diastrophism.
D. volcanism. **E.** exfoliation.

58. In a certain region, a series of sedimentary rock strata has been subjected to extensive folding. Therefore,
(1.10)

- **A.** any young valley in the area would be converted to a more mature stage.
- **B.** metamorphic rock is probably present in the area.
- **C.** igneous rock must be present in the form of sills and dikes.
- **D.** the sedimentary rock has been converted by pressure into clay and soil.
- **E.** the land surface is now thoroughly drained by a system of new young valleys.

59. In California, roads and stream beds are broken when they cross a line several hundreds of miles long. They are displaced some ten feet to one side when they cross the line. This is due to
(1.10)

A. volcanic action. **B.** landslides. **C.** erosion.
D. faulting. **E.** slumping.

60. Which of the following kinds of rock can be converted to magma by volcanism?
(1.10)

A. Sedimentary only. **B.** Igneous only.
C. Metamorphic only.
D. Only igneous and metamorphic.
E. Sedimentary, metamorphic, and igneous.

61. Diastrophism is most closely related to the formation of which of the following types of rocks?
(1.10)

A. Igneous. **B.** Metamorphic. **C.** Sedimentary.
D. Both sedimentary and metamorphic.

62. The formation of which of the following types of rocks is directly dependent on gradation?
(1.10)

A. Metamorphic only. **B.** Igneous only.
C. Sedimentary only.
D. Both sedimentary and metamorphic.

Items 63 - 68. After each item number on the answer sheet, blacken space

- **A.** if the item is most characteristic of mountains formed by erosion alone.
- **B.** if the item is most characteristic of mountains formed by volcanic activity.
- **C.** if the item is most characteristic of mountains formed by crustal movement.

63. All of the rocks in the mountains are igneous rocks.
(1.10)

64. The mountains are high ridges between streams.
(1.10)

65. The strata of rocks in the mountains are horizontal.
(1.10)

66. The rock strata are arched or folded.
(1.10)

67. Faulting has occurred on a gigantic scale.
(1.10)

68. The general appearance of such a mountain is that of a cone.
(1.10)

69. A joint in the lithosphere may be distinguished from a fault in that a joint
(1.10)

- **A.** may have a relative movement of several inches to several miles.
- **B.** may assume only horizontal directions.
- **C.** is a crack through which no differential movement has occurred.
- **D.** is caused by compressional forces.
- **E.** may have relative movement of not more than several hundred feet.

70. Which one of these is basically diastrophic in origin?
(1.10)

A. Dike. **B.** Fault. **C.** Batholith.
D. Alluvial fan. **E.** Esker.

71. An unconformity indicates
(1.10)

- **A.** deposition of large quantities of unsorted material in geosynclines.
- **B.** that a transitory feature definitely existed in the area at one time.
- **C.** a long period of erosion followed by submergence and sedimentation.

D. that igneous rock is usually beneath the sedimentary layers.
E. that mountains have been produced at one time due to differential erosion.

72. (1.10) Which one of these statements is true of a normal fault?

A. The hanging wall has moved up and over the foot wall.
B. Compressional forces move the hanging wall side down with respect to the foot wall.
C. It is convex upward.
D. It is produced by tensional forces.
E. It is a joint in which no differential movement of the crustal blocks has taken place.

73. (1.10) A normal fault results from

A. a lateral compression.
B. the elevation of a crustal block.
C. tensional forces. **D.** igneous intrusion.
E. forcing the hanging wall up over the foot wall.

74. (1.10) A normal fault

A. involves differential movement of crustal blocks.
B. is the technical name for joints in rock formations.
C. occurs from great compressional forces in the lithosphere.
D. is basically volcanic in origin.
E. raises the overall height of the section where it occurs.

75. (1.10) A normal fault

A. must be vertical.
B. is caused by compressional forces.
C. is a result of volcanism.
D. has no differential movement of the crustal blocks.
E. is one in which the hanging wall moves downward.

For items 76 - 78, choose from the key list that term most closely related to the statement comprising the item.

KEY

A. Batholith. **B.** Laccolith. **C.** Sill. **D.** Dike.
E. Neck.

76. (1.10) Intrusive lava was diverted from its upward path in a horizontal direction between two rock strata the upper of which is pushed upward into a dome shape.

77. (1.10) Intrusive masses of magma with relatively large diameter and indeterminate depth.

78. (1.10) In the area of extinct volcanoes, pillars and posts of resistant lava survive the more erosive surrounding materials.

79. (1.10) Igneous intrusions known as sills are

A. finger-like bodies projecting laterally from a volcanic rock.
B. tabular masses parallel to the bedding planes in the rock.
C. elongated bodies filling widened joints or faults.
D. dome shaped bodies of limited extent.
E. lava flows which were later covered by other rock.

80. (1.10) During the past 20 years, the water level of the Atlantic Ocean along the East Coast of the United States has been rising at a rate of about 18 inches per century. The principal cause of this rise in water level is most probably

A. the melting of glacial ice causing an increase in the volume of water in the ocean.
B. the gradual drainage of lake basins (such as the Great Lakes) causing an increase in the volume of water in the ocean.
C. a gradual subsidence of the eastern part of the United States.
D. a gentle upwarping of the ocean floor.
E. none of these.

81. (1.10) The seismograph is a valuable aid in all of the following except

A. investigating the nature of the rocks of the earth's crust.
B. investigating the composition of the earth's interior.
C. measuring the velocity of an earthquake wave.
D. predicting volcanic action.
E. predicting earthquakes.

82. (1.10) Of the gaseous volcanic products, the most abundant is

A. hydrochloric acid. **B.** hydrogen sulfide.
C. sulfur dioxide. **D.** carbon dioxide. **E.** water.

83. (1.10) A very explosive volcanic eruption would most likely be associated with magma

A. of high silica content and high gaseous content.
B. of low silica content and high gaseous content.
C. of high silica content and low gaseous content.
D. of low silica content and low gaseous content.
E. that contains no silica.

84. (1.10) The majority of mountain systems are formed principally by

A. folding. **B.** faulting. **C.** stream erosion.
D. volcanic activity.
E. the formation of domes by intrusive igneous activity.

85. (1.10) A tsunamis is a (an)

A. extensive tornado.
B. hurricane of unusual violence.
C. violent volcanic eruption.
D. poisonous, gaseous cloud originating from a volcano.
E. seismic sea wave.

86. (1.10) The most frequent cause of earthquakes is

A. folding. **B.** faulting. **C.** a landslide.
D. volcanic action. **E.** a seismic sea wave.

87. (1.10) The entrenched meanders and rejuvenated streams of the present Appalachian Mountains are evidence of

A. the formation of a new geosyncline.
B. the occurrence of crustal shortening resulting in re-elevation.
C. glacial action. **D.** slipping and faulting.
E. the presence of alternate layers of hard and soft rocks.

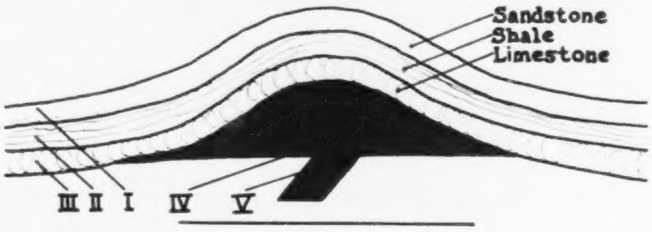
88. (1.10) Strata of limestone are intruded by a large mass of molten igneous rock. The limestone adjacent to the igneous mass is likely to be changed to

A. chert. **B.** marble. **C.** shale. **D.** slate.
E. marl.

89. When extrusive magma containing large quantities of
(1.10) entrapped gases cools, it may form

A. granite. **B.** obsidian. **C.** scoria.
D. andesite. **E.** rhyolite.

Items 90 - 94. After each exercise number on the answer sheet, blacken the *one* lettered space which designates the correct answer.



90. The umbrella shaped block formation is most likely
(1.10) composed of

A. igneous rocks. **B.** sedimentary rocks.
C. metamorphic rocks. **D.** quartz rocks.
E. feldspar rocks.

91. The rock formation immediately surrounding formation
(1.10) IV would probably be

A. slate. **B.** granite. **C.** marble. **D.** sill.
E. obsidian.

92. Any caves in the area would most likely be found in
(1.10) formation.

A. I. **B.** II. **C.** III. **D.** IV. **E.** V.

93. Formation V would be called an
(1.10)

A. esker. **B.** dike. **C.** bar. **D.** stem. **E.** sill.

94. Formation IV is a
(1.10)

A. batholith. **B.** volcano. **C.** volcanic cone.
D. sill. **E.** none of these things.

95. Which of the following *does not* occur at the surface
(1.10) of the earth?

A. Weathering. **B.** Degradation. **C.** Solifluction.
D. The development of magmas. **E.** Erosion.

96. From one good seismogram made by a single instru-
(1.10) ment at one station it is possible to determine

A. the approximate distance to the point of origin of the quake.
B. the approximate direction of the epicenter.
C. the approximate depth at which the disturbance occurred.
D. the nature of the material at the epicenter.
E. none of the above.

97. Which building would suffer the least damage during
(1.10) an earthquake?

A. One built on glacial till.
B. One built on kame terrace gravels.
C. One built on bedrock.
D. One built on old lake sediments.
E. All would suffer equally.

98. An Isobase
(1.10)

A. is the datum from which elevations are measured.
B. is a line drawn on a map connecting places of equal upwarp.
C. is a line drawn on a map connecting places which have equal amount of shaking during an earthquake.
D. is a part of a geosyncline from which mountains were made by uplift and folding.
E. could never be used for reckoning purposes except in New England or the Great Lakes region.

99. Which of the following mountain types *does not* suggest
(1.10) uplift and deformation?

A. Fault block mountains. **B.** Fold mountains.
C. Dome mountains. **D.** Volcanic cones.
E. Complex mountains.

100. Which of the following is *incorrect?*
(1.10)

A. Geologists have a good understanding of the origin of forces that cause mountain building.
B. Igneous rocks are abundant in most mountain regions.
C. Strong folding and faulting is characteristic of complex mountains.
D. Some mountain regions show evidence of several periods of folding and uplift.
E. Great thicknesses of sediment are found in folded mountain regions.

101. Which of the following is the most abundant consti-
(1.10) tuent of volcanic gases?

A. Hydrofluoric acid. **B.** Hydrogen sulphide.
C. Water vapor. **D.** Sulphur dioxide.
E. Carbon dioxide.

102. One of the following is not classified as pyroclastic
(1.10) material. Which one?

A. Lapilli. **B.** Blocks. **C.** Bombs. **D.** Lava.
E. Pumice.

103. An iso-seismal map shows
(1.10)

A. lines indicating equal time of arrival of earthquake waves.
B. lines indicating areas of equal intensity of earthquake shocks of a particular earthquake.
C. lines indicating the percentage of people who heard the quake.
D. the intersection of arcs drawn from three or more observatories that recorded one earthquake.
E. lines indicating areas of equal frequency of earthquakes over a span of many years.

104. In the great mountain belts the rocks are commonly
(1.10) folded into upfolds and downfolds. A single upfold is known as

A. a geosyncline. **B.** an anticline. **C.** a syncline.
D. an anticyclone. **E.** a reverse fault.

105. All of the features listed below except one are charac-
(1.10) teristic of the great orogenic mountain belts. Which one is the exception?

A. They occur in long linear arc-shaped belts.
B. They have been deformed by tremendous horizontal compressive forces.
C. They occur at the site of former geosynclines in areas of great thickness of sediments.
D. They are all broken by numerous normal faults and therefore were caused by great tension stresses.
E. Often they may be accompanied by volcanic activity and the injection of igneous rocks.

106. (1.10) Three, and only three, of the following highlands are basically old massifs, formed by block-faulting of eroded ancient mountains.

1. Slate Mountains. **2.** Rhodope Mountains.
3. Pamir Plateau. **4.** Rocky Mountains.
5. Apennine Mountains.

The faulted block highlands are

A. 1, 2, and 3. **B.** 3, 4, and 5. **C.** 2, 3, and 5.
D. 2, 4, and 5. **E.** 1, 2, and 5.

107. (1.10) Three, and only three, of the following regions are plateaus which are essentially great faulted blocks.

1. Atlas Mountains. **2.** Appalachian Mountains.
3. Black Forest. **4.** Slate Mountains.
5. Rhodope Mountains.

The faulted plateaus are

A. 1, 2, and 3. **B.** 3, 4, and 5. **C.** 2, 3, and 4.
D. 2, 3, and 5. **E.** 1, 3, and 5.

108. (1.10) Judging by the location of the great belt of crustal instability, which one of the following regions would be most likely to experience violent earthquakes?

A. Greece. **B.** Campos of Brazil.
C. Southwest Africa. **D.** Peninsular India.
E. Western Australia.

109. (1.20) Which of the following is the best reason for supposing that there is a sequential development of shoreline topography?

A. One may observe a shoreline developing through the several stages.
B. One can trace along a given shoreline a gradation from youth to maturity.
C. Submergent and emergent shorelines have observable systematic differences.
D. Various observed shorelines may be arranged in the order of a supposed sequence.
E. All landforms undergo some kind of sequential development and shorelines are a type of landform.

110. (1.22a) In order definitely to determine the location of an earthquake, three observatories are necessary because

A. there are three types of earthquake waves.
B. two observatories check on each other, a third is needed for a final check.
C. three circles then intersect in one point.
D. all three circles must be on the same straight line.
E. earthquakes often occur in remote areas.

111. (1.24) A strato-volcano is characterized by

A. a low, flat slope, and is built entirely of lava.
B. steep slopes, and is entirely of fragmental material.
C. alternating layers of lava and fragmental material.
D. a large central crater-like area that has collapsed.
E. a resistant central plug that forms a conspicuous topographic prominence.

112. (1.24) Which one of the following statements is correct concerning uplift of the land in Fennoscandia?

A. Determination of the amount of uplift depends entirely upon the relation of wave-cut beaches to present sea level.
B. No estimate of the total amount of upwarp can be made unless the determination has been made solely on the basis of water gauges that have been used to detect the change.
C. Old place names, diaries, and old maps may show something as to the total amount of uplift, provided such data is at least 5000 years old, for otherwise it cannot be compared with present sea level.
D. The uplift started soon after the ice began to melt and continued throughout the time the ice was melting.
E. Most of what is considered as upwarp could be explained by a lowering of sea level rather than an uplift of the land.

113. (1.25) The size of the earth's core is indicated by

A. the extent of the "shadow zone" on the opposite side of the earth from the focus of an earthquake, in which shadow zone the S waves are not recorded.
B. the extent of the "shadow zone" on the opposite side of the earth from the focus of an earthquake, in which shadow zone the P waves are not recorded.
C. the extent of the "shadow zone" where L waves are not recorded.
D. the extent of the area on the opposite side of the earth where L waves are not so strong as they are in other places.
E. the extent of the area on the opposite side of the earth where the S waves are not so strong as they are elsewhere.

114. (1.25) Seismic prospecting for petroleum is possible because

A. dynamite shatters the rocks without pulverizing them.
B. certain rock layers reflect the sound waves differently than others.
C. all rocks react in the same manner to the sound waves.
D. the explosion of the dynamite directly reveals the presence or absence of oil.
E. oil is found in earthquake regions.

115. (1.30) Batholiths, dikes, and sills are always

A. older than the sedimentary rocks they penetrate.
B. associated with volcanoes.
C. composed of igneous rock.
D. found only at great depths below the earth's surface.

116. (1.30) Isostacy is a geologic term which refers to

A. the formation of mountains due to batholithic intrusion.
B. the differential erosion of rocks.
C. the equilibrium between crustal segments.
D. breaks in the sedimentary process.
E. the theory of the magnetization of the earth.

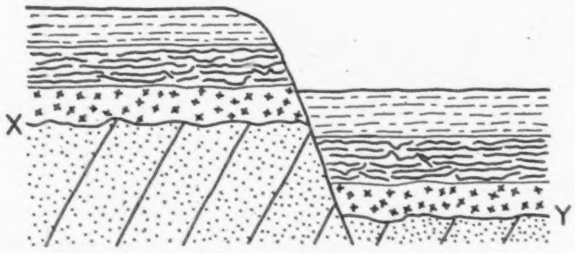
117. (1.30) The theory of isostasy states that

A. there is a slow lateral movement of continental portions of the lithosphere.
B. through accommodation at depth, portions of the lithosphere change elevation due to removal or accumulation of load.
C. the earth is slowly shrinking due to gradual loss of heat energy into the atmosphere.
D. the interior of the earth is becoming denser thus causing the crusted portion to shrink.
E. the earth was formed in cosmic time out of the material ejected from the sun.

118. The theory of isostasy is one explanation of diastrophic
(1.30) earth movements. This theory states that

A. the earth is slowly shrinking due to gradual loss of heat energy into space.
B. the interior of the earth is becoming denser thus causing the crusted portion to shrink.
C. through accommodation at depth, portions of the lithosphere change elevation in response to removal or accumulation of load.
D. there is a slow lateral movement of continental portions of the lithosphere.

For items 119 and 120 refer to the following diagram.



119. The fault shown in the diagram may be correctly called
(2.10)

A. a normal fault only. **B.** a thrust fault only.
C. either a normal or tension fault.
D. either a thrust or reverse fault.
E. either a thrust or compression fault.

120. The broken line x—y, between the horizontal strata
(2.10) and the slanting strata, represents

A. a syncline. **B.** an anticline. **C.** a dike.
D. an orogenic fold. **E.** an unconformity.

For items 121 - 124 evaluate these observations recorded during the California earthquake of April 18, 1906, according to this key.

KEY

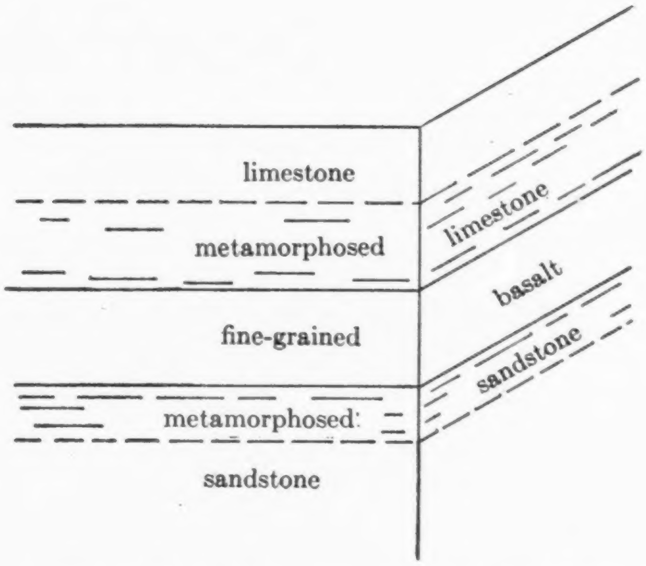
A. A phenomenon accompanying the primary waves.
B. A phenomenon accompanying the secondary waves.
C. A phenomenon accompanying the long waves.

121. On going outside he heard a great noise from the west
(2.10) and saw the tree tops waving. The noise and motion of trees approached him and he took hold of a small tree for support. The tree was torn from his grasp. The ground seemed to be in waves about 2 feet high and 15 feet long.

122. The San Lorenzo River was churned into foam, the
(2.10) banks crackling and settling several inches; and sand, said to have come from a depth of 100 feet, was forced up in several places.

123. During the earthquake, a cow fell into the fault crack
(2.10) and the earth closed in on her, so that only the tail remained visible. As the fault-trace in that neighborhood showed no cracks large enough to receive a cow, it would appear that there was a temporary parting of the walls.

124. An oil well, from which tepid salt water, oil, and gas
(2.10) had been flowing since 1898, became suddenly dry and a similar flow began in another well at a distance of 600 feet to the east of the first well.



125. Refer to the diagram above. The basalt probably rep-
(2.10) resents

A. a dike, intruded after the sandstone and limestone were deposited.
B. a batholith. **C.** a sill.
D. a lava sheet extruded on top of the sandstone and subsequently covered with a deposit of limestone.
E. a fine-grained layer of sedimentary rock.

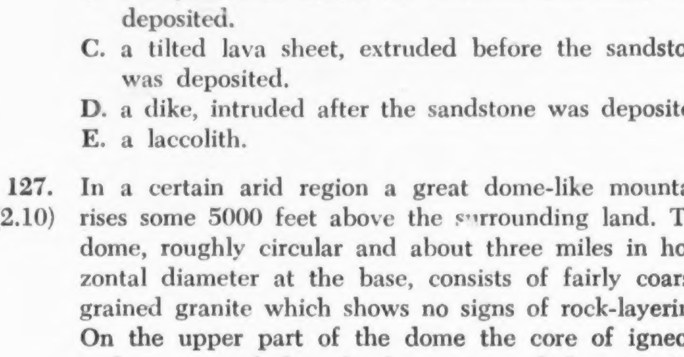
126. Refer to the diagram at the right. The coarse-grained
(2.10) granite probably represents

A. a dike, intruded through the layers of limestone and shale.
B. a sill, intruded before the limestone and shale were deposited.
C. a tilted lava sheet, extruded before the sandstone was deposited.
D. a dike, intruded after the sandstone was deposited.
E. a laccolith.

127. In a certain arid region a great dome-like mountain
(2.10) rises some 5000 feet above the surrounding land. The dome, roughly circular and about three miles in horizontal diameter at the base, consists of fairly coarse-grained granite which shows no signs of rock-layering. On the upper part of the dome the core of igneous rock is exposed, but the lower part of the mountain flank is covered by a layer of sedimentary rock which forms a warped-up continuation of rock strata of the surrounding land. Tests have shown that the igneous rock core extends downward indefinitely, with no known base. The mountain probably is

A. an eroded horst. **B.** an eroded batholith.
C. an eroded laccolith. **D.** an eroded anticline.
E. an eroded syncline.

Items 128 - 141 refer to the block diagram below. For each item, select the answer that correctly completes the item. The top of the block represents the land surface at the present time.



128. The symbol, B, represents
(2.10)

A. layers of igneous rock.
B. layers of sedimentary rock. **C.** an anticline.
D. a syncline. **E.** a batholith.

129. The strata represented by B were originally
(2.10)
or
(2.20)

A. the result of volcanic activity.
B. the result of diastrophism.
C. deposited below sea level. **D.** an unconformity
E. the result of glacial activity.

130. The strata represented by B were elevated because of
(1.10)

A. erosion. **B.** sedimentation. **C.** weathering.
D. diastrophism. **E.** faulting.

131. After elevation the erosion of the strata represented by B resulted in the formation of (1) now known as
(2.10)

A. a thrust fault. **B.** a tension fault. **C.** a syncline
D. an anticline. **E.** an unconformity.

132. The erosion resulting in (1) was followed most immediately by
(2.20)

A. subsidence and inundation. **B.** volcanic activity.
C. penetration of igneous material.
D. sedimentation. **E.** faulting.

133. The next stage was
(2.20)

A. faulting. **B.** sedimentation. **C.** erosion.
D. intrusion of igneous material. **E.** glaciation.

134. The next stage was
(2.20)

A. faulting. **B.** sedimentation. **C.** erosion.
D. an uplifting of the region.
E. subsidence and inundation.

135. The next stage was
(2.20)

A. faulting. **B.** intrusion of igneous material.
C. glaciation. **D.** sedimentation. **E.** metamorphism.

136. The next stage was
(2.20)

A. faulting. **B.** intrusion of igneous material.
C. glaciation. **D.** sedimentation. **E.** metamorphism.

137. The symbol 2 represents a
(2.10)

A. laccolith. **B.** batholith. **C.** sill. **D.** strike.
E. dip.

138. The symbol 3 represents a
(2.10)

A. batholith. **B.** laccolith. **C.** sill. **D.** dike.
E. fault.

139. The symbol 4 represents
(2.10)

A. a tension fault. **B.** a thrust fault. **C.** a strike.
D. an unconformity. **E.** a batholith.

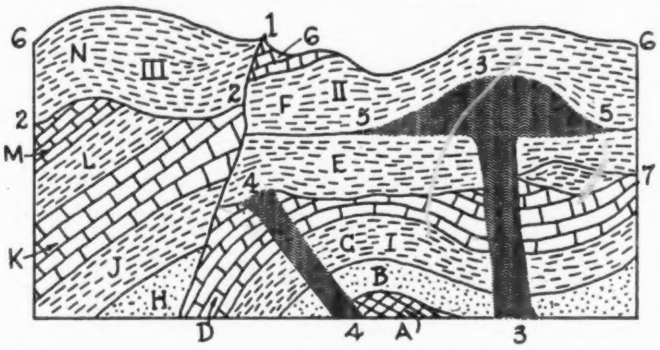
140. The symbol 5 represents
(2.10)

A. an unconformity. **B.** a dip. **C.** a strike.
D. a scarp. **E.** an anticline.

141. Two formations of the same geologic age are
(2.20)

A. 1 and 2. **B.** H and X. **C.** K and V.
D. N and W. **E.** L and Y.

Items 142 - 149 refer to the following diagram.



142. The doming along the upper part of 3 - 3 is caused by
(2.10)

A. a lava flow. **B.** the anticline I. **C.** a laccolith.
D. a sill. **E.** a batholith.

143. The dike 4 - 4 does not appear on the left side of the fault 1 - 1 because
(2.10)

A. the fault displaced the dike downward on the left side.
B. the intrusive force was not sufficient to push the intrusion any farther than pictured as its force was expended intruding 3 - 3.
C. E is a resistant bed. **D.** of an erosion interval.

144. There is evidence of a period of mountain building at
(2.10)

A. I. **B.** II. **C.** III **E.** 1 - 1.
E. none of these.

145. The bed B represents sandstone, C shale, and D limestone. It may be surmised that the land during this deposition was
(2.20)

A. sinking. **B.** being folded. **C.** being intruded.
D. rising. **E.** being faulted.

146. In the region depicted,
(2.20)

A. the faulting was the cause of the folding.
B. the folding was the cause of the faulting.
C. the faulting was the cause of the igneous intrusion.
D. the igneous intrusion 3 - 3 caused the folding.
E. none of the above is correct.

147. G is the same stratum as
(2.20)

A. M. **B.** K. **C.** D. **D.** none of the above.

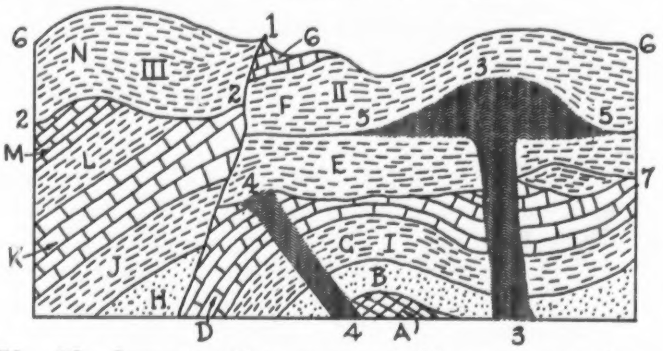
148. The oldest sedimentary formation is at
(2.20)

A. B. **B.** C. **C.** D. **D.** E. **E.** F.

149. There is evidence of a long period of erosion at
(2.10)

A. 1 - 1. **B.** 4 - 4. **C.** 5 - 5 **D.** 7 - 7. **E.** A.

Items 150 - 156 refer to the following diagram.



150. The formation N is most probably composed of
(2.10)

A. igneous rock. **B.** metamorphic rock.
C. sedimentary rock. **D.** mineral deposits.
E. none of these.

151. The formation 4 - 4 is a
(2.10)

A. sill. **B.** dike. **C.** laccolith. **D.** batholith.
E. fissure.

152. The formation 5 - 5 is a
(2.10)

A. sill. **B.** dike. **C.** laccolith. **D.** batholith.
E. volcano.

153. The feature 1 - 1 is a/an
(2.10)

A. reverse fault. **B.** normal fault.
C. unconformity. **D.** joint. **E.** scarp.

154. The feature 7 - 7 is a/an
(2.10)

A. syncline. **B.** anticline. **C.** normal fault.
D. reverse fault. **E.** unconformity.

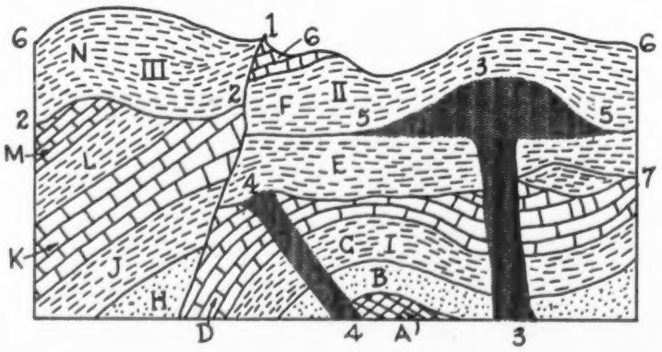
155. The feature at I is a/an
(2.10)

A. fault. **B.** joint. **D.** syncline. **D.** anticline.
E. unconformity.

156. The feature 2 - 2 is
(2.20)

A. younger than 7 - 7. **B.** the same age as 7 - 7.
C. older than 7 - 7. **D.** younger than 1 - 1.
E. younger than 3 - 3.

Items 157 - 163 refer to the following diagram.



157. There is a normal fault at the line indicated at
(2.10)

A. 1 - 1. **B.** 2 - 2. **C.** 7 - 7. **D.** 4 - 4.
E. none of the above.

158. There is a sill at the line marked
(2.10)

A. 5 - 5. **B.** 2 - 2. **C.** 1 - 1. **D.** 4 - 4.
E. none of the above.

159. There is evidence of a period of mountain building by folding at
(2.10)

A. I. **B.** II. **C.** III. **D.** 1 - 1.
E. none of the above.

160. The rocks at III are most likely to be
(2.10)

A. basalt. **B.** granite. **C.** sandstone.
D. gabbro. **E.** marble.

161. There is evidence of a period of erosion at
(2.10)

A. 1 - 1. **B.** 4 - 4. **C.** 7 - 7. **D.** 5 - 5.
E. none of the above.

162. The oldest sedimentary formation listed below is at
(2.20)

A. L. **B.** B. **C.** C. **D.** D. **E.** G.

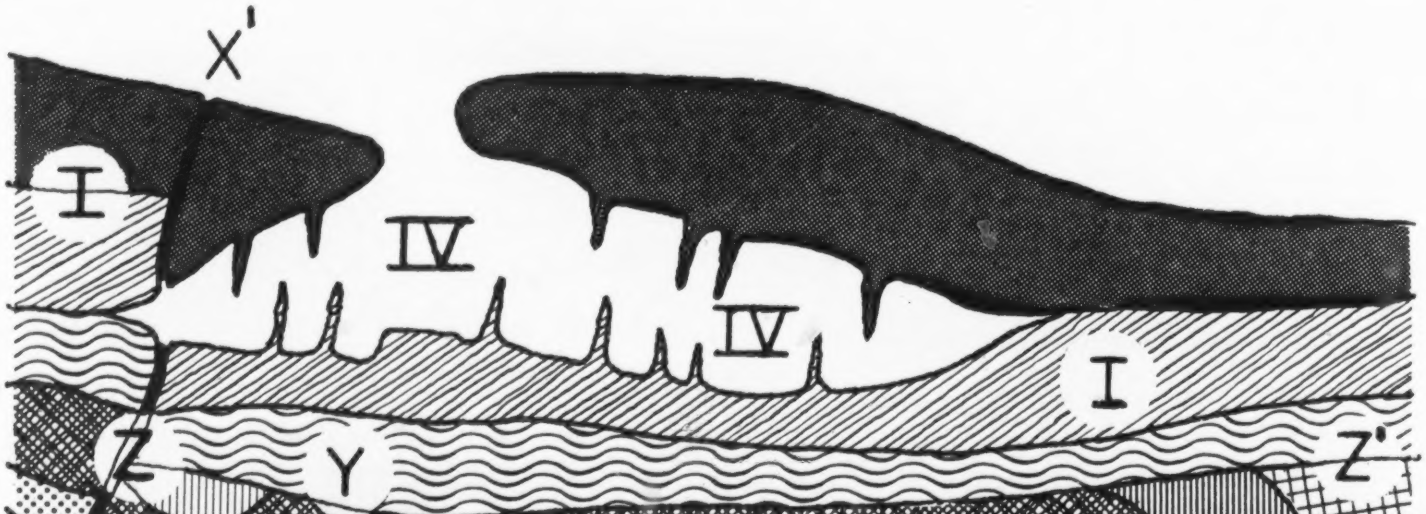
163. Two rock formations of the same age are
(2.20)

A. K and D. **B.** J and E. **C.** M and G.
D. M and D. **E.** none of the rock formations.

Items 164 - 176 refer to the diagram at the bottom of this page.

164. In the diagram there is *no* example of
(2.10)

A. a recent period of diastrophism.
B. an ancient period of diastrophism.
C. a recent period of gradation.
D. an ancient period of gradation.
E. a recent volcanic disturbance.



165. In the diagram there is *no* example of
(2.10)

A. a tension fault. **B.** a thrust fault.
C. an unconformity. **D.** an anticline.
E. a syncline.

166. Formation IV was made by
(2.10)

A. wind erosion. **B.** running water.
C. ground water. **D.** ice. **E.** waves.

167. The rock in III is most likely to be
(2.10)

A. limestone. **B.** granite. **C.** quartzite.
D. conglomerate. **E.** marble.

168. The rock in I is most likely to be
(2.10)

A. limestone. **B.** slate. **C.** obsidian.
D. granite. **E.** gneiss.

169. The rock in II cannot be
(2.20)

A. shale. **B.** granite. **C.** limestone.
D. sandstone. **E.** schist.

170. The most ancient event labeled in the diagram, with
(2.20) the possible exception of III, is the

A. formation of XX′. **B.** formation of IV.
C. formation of YY′. **D.** formation of II.
E. formation of I.

171. XX′ was formed before
(2.20)

A. YY′ was made.
B. the rocks in I were deposited.
C. ZZ′ was made.
D. the rocks in II were formed. **E.** IV was made.

172. The fact that remains of marine animals have been
(1.10) found far inland is evidence of

A. volcanism. **B.** diastrophism. **C.** gradation.
D. erosion. **E.** exfoliation.

173. It is possible to tell whether a rock has been formed
(1.10) close to the surface or at great depths by its

A. color. **B.** crystal size. **C.** composition.
D. acidity.

174. A sedimentary rock whose sediments consist of clay or
(1.10) mud is known as

A. shale. **B.** limestone. **C.** chert.
D. conglomerate. **E.** sandstone.

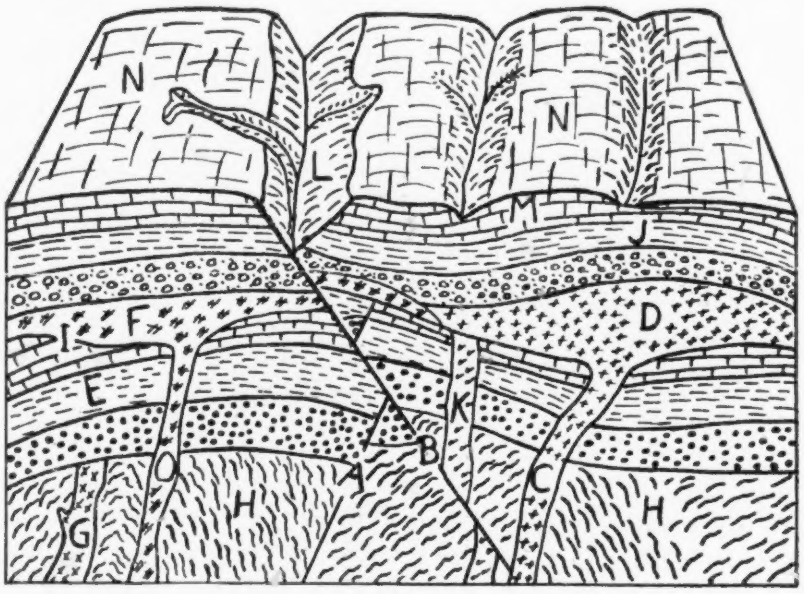
175. The metamorphic equivalent of granite is
(1.10)

A. marble. **B.** quartzite. **C.** a gneiss.
D. a schist. **E.** a slate.

Items 176 - 189 refer to the block diagram at the right, in which various geologic features are designated by letters A, B, C, etc. Complete each of the statements by marking on the answer sheet the number of the word or phrase which makes it a true statement.

176. Fault B is a
(2.10)

A. strike-slip fault. **B.** normal fault.
C. reverse fault.



177. Granite D is a
(2.10)

A. dike. **B.** sheet. **C.** laccolith.

178. Granite C is a
(2.10)

A. sill. **B.** dike. **C.** sheet.

179. Granite D was emplaced
(2.20)

A. before fault B. **B.** before shale J.
C. later than all of the other rock formations represented.

180. The folding of E took place
(2.20)

A. before the formation of F.
B. at the time of faulting at B.
C. after the faulting at B.

181. The fold represented at E is a/an
(2.10)

A. syncline. **B.** anticline. **C.** geosyncline.

182. The contact at I is a/an
(2.10)

A. fault plane. **B.** joint. **C.** old erosion surface.

183. The gneiss at H is
(1.10)

A. sedimentary. **B.** metamorphic. **C.** igneous.

184. The stream in valley L is in the stage of
(2.10)

A. maturity. **B.** old age. **C.** youth.

185. The valley was formed along a
(2.10)

A. syncline. **B.** fault plane. **C.** joint crack.

186. Dike K was formed
(2.20)

A. after the time of the intrusion at D.
B. before the faulting at B.
C. at the time of deposition of limestone M.

187. Sedimentation is represented by formation
(2.10)

A. M. **B.** D. **C.** H.

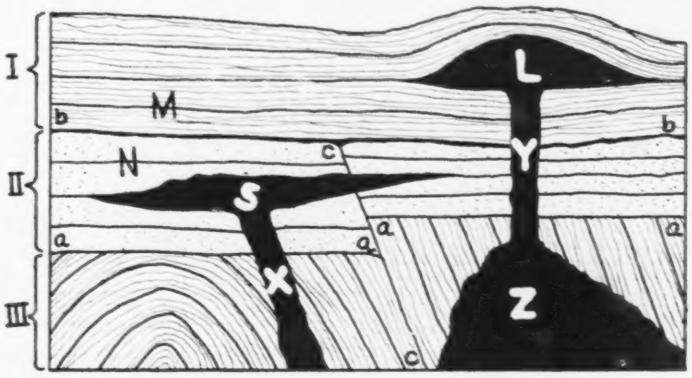
188. Of the three features listed below, the youngest is
(2.20)

A. fault B. **B.** stream valley L.
C. limestone surface N.

189. The oldest formation represented in the diagram is
(2.20)

A. gneiss H. **B.** granite dike G. **C.** limestone M.

Items 190 - 207. The diagram below represents a canyon wall with rocks exposed to view. The white beds are sediments, and the black features igneous. X and S are of the same age. X is not necessarily the same age as Y. Line *aaaa* and *bb* are erosional unconformities. Line *cc* is a fault. After each item number on the answer sheet, blacken the *one* lettered space indicating the correct answer.



190. The sedimentary rocks of III were
(2.10)

A. originally formed in tilted layers.
B. folded by the intrusion of igneous rock.
C. folded and tilted by diastrophism.
D. deposited at a bend of a river.

191. The correct answer to Item 190 is in agreement with
(1.30) the fact that

A. a river current is always more rapid close to the banks.
B. horizontal layers of sedimentary rock may be distorted by crustal movements.
C. magma may cause sedimentary rock to fold.
D. variation in ocean storms produces irregularity of deposition of sediments.

192. Before the sedimentary rocks of II could be super-
(2.20) imposed on those of III, there must have occurred a long period of

A. exfoliation and weathering.
B. erosion and subsequent submergence.
C. volcanism and gradation.
D. unconformity and faulting. **E.** metamorphism.

193. The forces which formed fault *cc*
(2.20)

A. were tensional. **B.** were compressional.
C. cannot be determined.

194. The correct answer to item 193 is supported by the
(1.10) fact that

A. the slope of the fault is steep and therefore could have been formed by either tensional or compressional forces.
B. the block to the left has been "pushed up" relative to that on the right.
C. the hanging wall has moved up relative to the foot wall.
D. diastrophic movements are often associated with tensional forces.
E. the intrusion of dike Y heated the block on the right and made it expand upward.

195. There is no fault scarp because
(1.10)

A. a fault scarp cannot form below strata of superimposed rocks.
B. fault scarps are formed only by the action of ground water.
C. glacial action is absent.
D. erosion preceded the deposition of I.
E. the formation of X and S destroyed all traces of a fault scarp.

196. The layers of sedimentary rock II are horizontal be-
(1.10) cause

A. they were tilted to this position by diastrophism.
B. they were formed in this manner and were not subsequently disturbed.
C. the pressure of rocks of I has caused them to assume this position.
D. they were melted by igneous rocks and on cooling formed these layers.
E. the rocks were formed in this manner and were not tilted by subsequent diastrophic movement.

197. According to the diagram there could have been more
(2.20) than three eras of deposition of sedimentary rock if

A. deposition during several eras occurred in the same region of the diagram as II.
B. an era of deposition is masked by the intrusion of igneous rock.
C. faulting had not occurred.
D. the deposition of sedimentary rock during these eras was followed by diastrophism and sufficient exposure to erosive agents to completely remove all trace of the rock of these additional eras.

198. It is no longer possible for other layers of sedimentary
(1.10) rock to form in the future unless

A. igneous rock breaks through to the surface.
B. submergence again occurs.
C. aggradation is the principal phenomenon occurring at the present time.
D. talus slopes are forming in the region of the fault.
E. weathering removes the material necessary for the formation of sedimentary rock.

199. Formation X is known as a
(2.10)

A. dike. **B.** laccolith. **C.** sill. **D.** magma.
E. scarp.

200. Formation S is known as
(2.10)

A. a silo. **B.** an esker. **C.** a moraine.
D. a terrace. **E.** a sill.

201. Formation Z is known as a
(2.10)

A. geyser. **B.** hot spring. **C.** volcanic island.
D. batholith. **E.** laccolith.

202. The correct answer to item 201 is the appropriate term
(1.10) to apply to formation Z, because

A. this is the term given to all beds of igneous rock formed at or near the surface rather than at great depths.
B. the rocks making up the formation are basalt.
C. it is igneous and enlarged downward.
D. in its formation, layers of sedimentary rock were displaced upward.
E. the magma has cooled down and formed solid igneous rock.

203. When formation L was formed, it caused the formation of
(2.10)

A. a geosyncline. **B.** an anticline.
C. a terminal moraine. **D.** a cirque.
E. a terrace above it.

204. Formation X is
(4.20)

A. older than formation Y.
B. younger than formation Y.
C. of the same age as formation Y.
D. of unknown age in relation to formation Y.

205. The correct answer to item 204 is in agreement with the fact that
(1.10)

A. all such formations in a given region are contemporaneous.
B. neither formation X nor fault *cc* cuts through unconformity *bb*, whereas formation Y does.
C. fault *cc* is younger than formation Y because fault *cc* probably cuts formation Y at a lower point than is shown on the diagram.
D. L-Y was formed after formation X was intruded.
E. insufficient information is given.

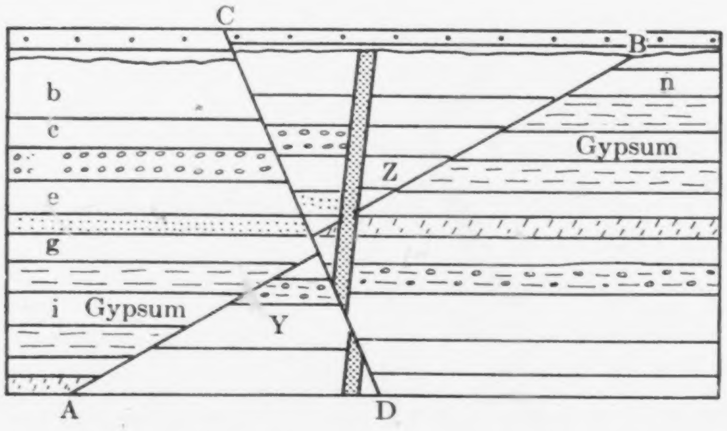
206. Formation Y is
(4.20)

A. younger than fault *cc*. **B.** older than fault *cc*.
C. of the same age as fault *cc*.
D. of unknown age in relation to fault *cc*.

207. The correct answer to item 206 is supported by the fact that
(1.10)

A. diastrophism and volcanism usually occur together.
B. the bed M is intruded by formation Y, yet is not cut by fault *cc*.
C. both formation Y and fault *cc* cut beds H.
D. formation Y and fault *cc* do not cut each other.
E. not enough data are given.

Items 208 - 213 refer to the following diagram which represents a cliff made up of a series of sedimentary strata originally deposited in marine water, which is cut through by a granite dike.



For each item, 208 - 213, select from the key the most appropriate response.

KEY

A. The statement is true. **B.** The statement is false.
C. The evidence for the statement is not conclusive.
D. There is no means of determining the truth or falsity of the statement.

208. The layer b has been under the sea at least twice.
(2.20)

209. Fault CD is a reverse fault.
(2.10)

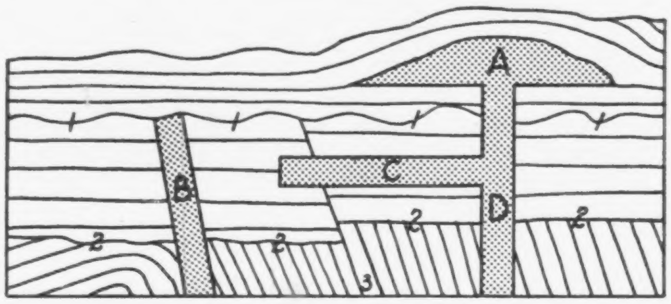
210. Stratum e is more resistant than stratum y.
(2.20)

211. The faulting of AB and CD caused the intrusion of igneous material.
(1.10)

212. The fault CD is older than fault AB.
(2.20)

213. The dike is older than fault AB.
(2.20)

Items 214 - 221 refer to the following diagram of an exposed wall section of rocks. The lighter-lined sections are sedimentary rock and the blackened sections are igneous rock.



214. The oldest sedimentary rocks are
(2.20)

A. above line 1-1-1-1. **B.** above line 2-2-2-2.
C. below line 2-2-2-2.
D. indeterminate without more information.

215. A fault is shown at
(2.10)

A. 1-1-1-1. **B.** B. **C.** the left along line 2-2.
D. the right along line 2-2. **E.** 3-3.

216. The sedimentary rocks below 2-2-2-2 were probably
(2.20)

A. originally formed in a tilted position.
B. deposited at the bend of a river.
C. warped by uplift or depression of the region.
D. folded and tilted by diastrophism.
E. folded by glacial action.

217. Line 2-2-2-2 represents a long period of
(2.10)

A. erosion followed by sedimentation.
B. metamorphism. **C.** volcanism and igneous activity.
D. exfoliation and weathering. **E.** faulting.

218. The geologic feature marked A is a/an
(2.10)

A. volcanic cone. **B.** laccolith. **C.** batholith.
D. dike. **E.** esker.

219. The geologic feature marked B is a
(2.10)

A. dike. **B.** scarp. **C.** fault. **D.** sill.
E. batholith.

220. The geologic formation B is
(2.20)

A. older than formation C.
B. younger than formation C.
C. of the same age as formation C.
D. of unknown age in relation to C.

221. (1.30) The answer to the preceding item is in agreement with the statement that

A. all formations like this in a given region occur at the same time.
B. any igneous rock is younger than any other rock which it cuts.
C. 3-3 is probably younger than C because D could cut 3-3 at a lower depth.
D. D and C were intruded before B was intruded.
E. insufficient information is given.

222. (2.20) A three component seismogram can indicate the approximate direction of the focus of an earthquake because

A. the P waves travel along the surface of the earth.
B. the P waves have a push-pull motion and their first motion is always a push out from the focus.
C. the P waves travel slower than S waves and would be recorded later.
D. the S waves have a push-pull motion and their first impulse is always a push out from the focus.
E. a time distance graph allows one to determine time, distance, and direction of the quake.

223. (2.40) The genetic relationship of some earthquakes to faults is shown by all but one of the following statements. Which one is the exception?

A. Earthquakes very commonly occur in areas of recent mountain growth.
B. The focus of some earthquakes can be traced to known faults either by isoseismal maps or by direct observation.
C. After some earthquakes actual displacement along faults has been observed.
D. The great earthquake belts on the earth do not correspond to areas of modern faulting.
E. The elastic rebound motion along a fault is the cause of many surface or shallow focus earthquakes.

224. (2.40) In the Appalachians, as well as almost all other mountain systems, the present mountainous surface (the topographic relief) is due to

A. normal faulting which tipped up large blocks.
B. the ridges and valleys corresponds to anticlines and synclines respectively.
C. the erosion of the mountain areas by ice sheets.
D. the mountainous surface is the direct result of mountain building rather than of erosion.
E. the erosion of resistant and unresistant rocks which previously had been deformed by tremendous horizontal forces.

225. (3.00) Mountain X is composed mainly of sedimentary rock. Where the rock strata have been exposed, they are found to be horizontal with no dips. The top of the mountain is relatively flat except where it has been eroded by surface run-off. The surrounding terrain is relatively flat with few hills and valleys in evidence. Mountain X was most likely caused by

A. erosion of a syncline. **B.** faulting.
C. erosion of a lava sheet. **D.** an abandoned cirque.
E. folding.

226. (3.00) Much of the copper mined in the Upper Peninsula of Michigan fills cavities in a lava called basalt. The most probable inference to be drawn from this would be that

A. at one time rather fluid lava was extruded over that area.
B. copper is made from magmatic materials.
C. the copper has been produced above the lava flow and gravity has distributed it downward into the lava.
D. copper should be found wherever basalt formations occur.
E. magmatic bombs, ejected from a fissure in the earth, fell in the Upper Peninsula.

227. (3.00) Assume that the duration of P waves as recorded on a seismogram was 3 minutes and 30 seconds. The approximate distance to the focus would be

A. 2173 miles. **B.** 1552 miles. **C.** 621 miles.
D. 4346 miles. **E.** 4.5 megameters.

228. (3.00) Assume that the duration of P and S waves as recorded on a seismogram was 9 minutes and 30 seconds. The approximate distance to the focus would be

A. 1966 miles. **B.** 5300 miles. **C.** 966 miles.
D. 7200 miles. **E.** 720 miles.

229. (3.00) Evidence for the Acadian mountain building epoch in the Hanover region is

A. Pleistocene gravels unconformable on Devonian rocks.
B. folding metamorphism, faulting, and intrusion of granites after the deposition of the Littleton formation.
C. a pronounced angular unconformity between the Silurian and Ordovician rocks and the intrusion of granites.
D. the Ordovician and Silurian rocks are made up of a great variety of volcanic rocks derived from volcanoes in the Acadian mountains.
E. not present.

230. (4.10) Which of the following statements concerning mountain building is largely an hypothesis rather than the statement of a fact based on extensive observational evidence?

A. Deposition of large quantities of erosional materials has accumulated in geosynclines.
B. Crustal movements have folded the strata formed in geosynclines into mountains.
C. Mountains have been produced by faulting on a gigantic scale.
D. Heavy minerals have tended to sink toward the center of the earth forcing the lighter segments upward.
E. Mountains have been produced by the differential erosion of rocks.

11. *Uniformitarianism*

UNIFORMITARIANISM

1. According to the principle of uniformitarianism the sur-
(1.30) face of the earth is changing due to processes such as

A. building up and wearing away of the surface.
B. movements of different parts of the earth's crust.
C. sudden vast changes of large areas of the earth's crust.
D. volcanic action.

2. Scientists carefully study geological processes which are
(1.30) going on at present. From the data thus obtained, they can understand processes of past geological ages. This type of reasoning involves the principle of

A. catastrophism. B. Darwinism.
C. uniformitarianism. D. metamorphicism.

3. When geologists assume that the forces modifying the
(1.30) earth today operated similarly in ages past they are accepting as true the laws of

A. organic correlation. B. uniformitarianism.
C. superposition. D. unconformity.

4. Contrast two theories:
(6.2)

1. The uniformitarian view of a long earth history with slowly shifting and changing sites of deposition and erosion, and through it life developing and changing slowly by the evolutionary process.
2. A view that all forms of life of which we have any knowledge lived contemporaneously, and then were destroyed rather quickly by a series of tidal waves or convulsions (which made unconformities). The weaker forms of life died first, then the next weaker, etc., so that the fossils are thus piled in the rocks in the definite order and succession in which we find them.

Which of the following statements is justifiable?

A. Theory 2 is utter nonsense.
B. Theory 1 is correct. Geology has proved that this is the way things happened.
C. Theory 2 is not useful. No correlation of sedimentary beds could be made for use in oil prospecting and mapping.
D. Theory 2 is as good a theory as 1 because evidence from other fields is not pertinent; this is solely a geological theory.
E. Convergence of evidence and certain esthetic and logical considerations incline scientists toward theory 1.

12. Earth History—
Interpretation of Fossils

EARTH HISTORY—INTERPRETATION OF FOSSILS

1. (1.10) An estimate of the age of the earth can be made most accurately from studies based upon

A. measurements of the total thickness of the outer crust.
B. the type of fossils in rocks.
C. chemical analysis for uranium and lead in igneous rock.
D. tree-ring data.
E. rate of recession of waterfalls.

2. (1.10) Plant fossils are relatively scarce because

A. plants came last in evolution.
B. all fossil space is taken by animals.
C. plants have no easily preserved parts.
D. most plants are formed into coal instead of being fossilized.
E. most plants are utilized by animals so that they are not available for fossilization.

3. (1.10) The oldest rocks now exposed at the earth's surface show

A. the truth of the Genesis account of world creation.
B. fossils of plants and animals present at the time of the formation of the rocks.
C. the action of strange geological processes.
D. evidence of processes which go on at present.
E. that the earth was originally part of the sun.

4. (1.10) Which of the following would offer the best basis for concluding that a layer of sandstone along the west coast of the United States was deposited about the same time as a certain layer formed on the east coast?

A. Each has the same chemical composition.
B. Each has the same physical characteristics.
C. They are the same distance below the surface of the earth.
D. They contain similar fossil remains.
E. They are the same number of rock layers beneath the surface.

5. (1.10) In order to calculate the age of the earth from a radioactive element, which one of the following should be known?

A. The total mass of the radioactive element.
B. The total life of the radioactive element.
C. The ratio of lead to the radioactive element.
D. The ratio of the mass of the radioactive element to the mass of rock of which it is a part.
E. The frequency of radio waves being emitted by the element.

6. (1.10) The unconformity can be dated in which of the following senses?

A. As occurring after the time when the organisms represented by fossils in the tilted beds lived, and before the time when the organisms represented by fossils in the horizontal beds lived.
B. In the sense that a study of certain features of the unconformity surface will indicate how long it took to form it.
C. As having formed a definite number of years ago.
D. The duration of the erosion necessary to form the unconformity may be determined by angle of tilt of the beds below it as compared to that of the beds above it.

7. (1.10) In order to consider the unconformity as a record of erosion, which of the following would be the best evidence?

A. The finding of horizontal strata on tilted strata.
B. The discovery that currents and waves out in the sea cannot erode rock into a flat surface.
C. The discovery that a great interval of time elapsed between the deposition of the beds immediately below the unconformity and those above it.
D. The discovery of points of similarity between the (buried) surface or the unconformity "plane" and land surfaces of the present day.
E. The determination that the unconformity surface is of too great an extent to be considered a wave cut cliff.

8. (1.10) A bedrock showing striae, which was determined to be of the rock type defined as tillite (consolidated till), would indicate for its area:

A. no periods of glaciation.
B. at least one period of glaciation.
C. two distinct and separate periods of glaciation.
D. three distinct and separate periods of glaciation.

9. (1.10) Remains of marine creatures are found contained in rocks exposed in mountainsides. Which of the following best explains this phenomenon?

A. The ocean once covered the mountains, but has now retreated.
B. These creatures lived in fresh water in the past.
C. During the past salt lakes were formed in the mountains by evaporation.
D. The mountains were produced by uplift and erosion of marine sediments.
E. All sedimentary rocks are marine deposits.

10. (1.10) Which of the following *could* be cited as *observational* evidence that the core of the earth is solid? (The statement need not necessarily be true.)

A. The earth is almost perfectly spherical.
B. Transverse earthquake waves are transmitted through the center of the earth.
C. Transverse (secondary) earthquake tremors can be detected on the opposite side of the earth from the quake.
D. Pressure increases enormously with increasing depths.
E. A rotating globe of liquid loses matter by centrifugal force; no such loss can be detected for the earth.

11. (1.10) Evidence in the present state of Michigan for the existence of arid or desert-like climates in its past history is contained in

A. large salt deposits.
B. limestone containing fossil corals.
C. sand dunes on the shore of Lake Michigan.
D. glacial drift covering most of the state.
E. marine deposited shale.

12. (1.10) Marine Triassic rocks in the eastern United States are:

A. red beds. **B.** a thick limestone sequence.
C. recognized by dinosaur footprints. **D.** widespread.
E. non-existent.

13. Cretaceous rocks are
(1.10)

A. highly folded in the eastern U.S.
B. widespread chalk deposits in the Great Plains area.
C. coal-bearing in the eastern U.S. only.
D. least widespread geographically of all Mesozoic rocks.
E. characterized by fossils of small and unspecialized dinosaurs.

14. The mountains built at the close of the Mesozoic were
(1.10)

A. the Sierra Nevadas of California and Nevada.
B. the Coast Ranges of Oregon.
C. the Laurentian Mountains of Colorado and Wyoming.
D. the Cascadian Mountains of the Pacific Southwest.
E. the Laramian Mountains of Colorado and Wyoming.

Items 15 - 17. Five rock types are listed below. Select the correct answer to these questions from this list and mark the appropriate number on your answer sheet.

A. Red beds. B. Coal. C. Basalt. D. Salt.
E. Obsidian.

15. Which type of rock listed above is most characteristic
(1.10) of the Silurian?

16. Which type of rock listed above is very abundant in
(1.10) the Pre-Cambrian?

17. Which type of rock listed above is most characteristic
(1.10) of the Pennsylvanian?

Items 18 - 21. Five geologic time units are listed below. Select the correct unit, and place the appropriate number on your answer sheet.

A. Pre-Cambrian. B. Silurian. C. Pennsylvanian.
D. Cretaceous. E. Tertiary.

18. The greatest quantity of nickel is produced from the
(1.10) rocks of which time unit?

19. The greatest quantity of petroleum is produced from
(1.10) rocks of which time unit?

20. From rocks of which time unit is the largest tonnage
(1.10) of iron ore mined?

21. From rocks of which time unit is the largest tonnage
(1.10) of coal mined?

22. Evolutionary change in the horse is shown by
(1.10)

A. change from larger to smaller animal.
B. increase in number of toes on front feet.
C. adaptation of teeth for grazing.
D. shortening of neck and skull.
E. change from herbiverous to carniverous.

23. Which statement concerning the geologic history of man
(1.10) is correct?

A. Saber-tooth tigers became extinct before man appeared.
B. Geologic evidence proves that man was present in Europe earlier than in North America.
C. Man is a direct descendent of living apes.
D. Geologic evidence indicates that man was present in North America earlier than in Europe.
E. Man is less than 100.000 years old.

24. Why are fossil men very scarce?
(1.10)

A. There were few individuals.
B. Did not possess sufficient hard parts.
C. Possessed high intelligence.
D. Human bones cannot be pyritized.
E. Man had limited geographic distribution in Pleistocene.

25. Man probably migrated into North America
(1.10)

A. during an interglacial period of the Pleistocene.
B. about 400,000 years ago.
C. by way of Greenland and Iceland.
D. during a glacial epoch of the Pleistocene.
E. across a land bridge in the North Atlantic.

26. Carbonized fossils are chiefly
(1.10)

A. brachiopods. B. plants. C. corals.
D. dinosaurs. E. trilobites.

27. Which mineral may replace brachiopod shells?
(1.10)

A. Halite. B. Amphibole. C. Chlorite.
D. Pyrite. E. Feldspar.

28. Pleistocene invertebrate fossils are
(1.10)

A. chiefly replaced by pyrite. B. poorly preserved.
C. half marine and half non-marine.
D. are almost wholly unreplaced shells.
E. mostly mammals.

29. Pennsylvanian wheat grain shaped fossils are known as
(1.10)

A. eurypterids. B. fusulines. C. sponges.
D. gastropods. E. arthropods.

30. A horizontal bed of Pennsylvanian limestone directly
(1.10) overlies a horizontal bed of Ordovician shale. This condition is described as

A. an intrusion. B. an angular unconformity.
C. a normal fault. D. an overturned bed.
E. a disconformity.

31. Which list is made up entirely of extinct organic forms?
(1.10)

A. Dinosaurs, trilobites, corals, flying reptiles.
B. Dinosaurs, trilobites, scale trees, saber-tooth tigers.
C. Dinosaurs, trilobites, sponges, fusulines.
D. Dinosaurs, trilobites, ferns, titanotheres.
E. Dinosaurs, trilobites, pelecypods, graptolites.

32. Coal beds in the Pennsylvanian indicate
(1.10)

A. mountain building. B. dry climates.
C. swampy conditions.
D. extensive and long-continued marine invasions.
E. extensive forests in upland areas.

33. Most of the features of the present day landscape were
(1.10) formed during the

A. Cambrian. B. Tertiary. C. Silurian.
D. Mesozoic. E. Quaternary.

34. Rock salt deposits in the earth were formed
(1.10)

A. from calcite.
B. from metamorphosis of igneous rocks.
C. by neutralization of NaOH in the rocks with HCL.
D. by the cooling of molten halite.
E. by the evaporation of sea water.

35. (1.10) Geologic eras

A. are of equal length.
B. are shorter lengths of time than geologic periods.
C. cover the estimated total age of the earth.
D. represent time intervals between major breaks in the sedimentary process.
E. are based on sequences in glaciation due to periodic refrigerations.

36. (1.10) After the early Paleozoic sediments were deposited

A. much faulting occurred in the region.
B. the edges of the continent rose and fell but the middle remained under water.
C. the central part of the continent gently raised once and there it remained.
D. the central part raised and lowered many times as is shown by successive layers of sedimentary rock.
E. mountains formed on the edges of these sediments during the Cenozoic Era.

37. (1.10) Which one of the following would offer the best basis for concluding that a certain layer of shale in New York was deposited at the same time as one in California?

A. They are the same distance below the surface.
B. They contain similar fossil remains.
C. They have the same chemical composition.
D. They are both sedimentary rocks.
E. Each one is between two sandstone layers.

38. (1.10) Abundant plant life, mild climate, and widespread swampy land in central United States characterized

A. the early part of the Paleozoic era.
B. the last part of the Paleozoic era.
C. a long period following the middle part of the Paleozoic era.
D. the time preceding the Paleozoic era.

39. (1.10) Which of the following would cause geologists to reject a given fossil as an index fossil?

A. It is found in the rocks of more than one continent.
B. It is found in layer after layer of sedimentary rock separated by unconformities.
C. It is easy to identify.
D. It contains none of the material composing the original organism, all of which has been replaced by calcium carbonate or silicon dioxide.

40. (1.10) The first part of the Paleozoic era was characterized by

A. submergence of a large part of North America.
B. formation of the great coal deposits.
C. elevation of land in the eastern part of the United States to form the Appalachian Mountains.
D. evaporation of seas resulting in extensive salt deposits.

41. (1.10) Which of the following must first occur for a geosyncline to become filled with layers of sedimentary rock?

A. Evaporation of inland seas.
B. Submergence of the area containing the geosyncline.
C. Erosion of rocks in nearby regions.
D. Shortening of the earth's crust in the region.

42. (1.10) Which of the following occurred at the end of the Paleozoic era?

A. Deposition of Niagara limestone.
B. Formation of great geosynclines.
C. Crustal shortening and folding of strata.
D. Formation of the great coal deposits.
E. Extensive glaciation.

43. (1.10) The present shape of the Great Lakes is due chiefly to

A. down-washing of the earth's crust.
B. glacial gouging of rock strata of varying hardness.
C. water from the melting glacier.
D. alternate elevation and submergence of the region.
E. side-slipping of the Niagara limestone from Niagara Falls to Lake Michigan.

In mixed order the following are the five principle stages taking place during a typical geological era.

1. The accumulation of great strains in the earth's crust which is relieved by mountain building.
2. The occurrence of widespread crustal movements which submerge certain large areas of the continents and elevate others.
3. The culmination and dominance of the forms of animal and plant life most characteristic of the era.
4. The occurrence of long periods of erosion accompanied by accumulation of sediments in regions of low elevation.
5. The formation of great geosynclines.

44. (1.22) Which of the following answers designates the first stage and the last stage in correct order?

A. 1 and 2. **B.** 2 and 1. **C.** 5 and 3.
D. 3 and 4. **E.** 4 and 2.

45. (1.22) Which of the following answers designates two stages which occur in conjunction with each other?

A. 1 and 5. **B.** 2 and 4. **C.** 3 and 5.
D. 4 and 5. **E.** 2 and 3.

Items 46 - 48. Choose from the key list of geologic eras the era most represented by the statements.

A. Cenozoic. **B.** Mesozoic. **C.** Paleozoic.
D. Proterozoic. **E.** Archeozoic.

46. (1.10) The earth was dominated by coal forming flora. The Appalachian mountains were made during the era.

47. (1.10) Extensive volcanism in Western United States followed by ice invasions and retreats. Large lakes formed in central and western states.

48. (1.10) Marked the formation of many of the igneous rocks of the Upper Peninsula of Michigan. Evidence of life must be limited to inferences.

49. (1.10) Geologic time has been divided into eras with the borderline determined by evidence of marked changes in

A. the characteristics of all plants and animals.
B. the characteristics of some plants and animals.
C. the shifting of continental and oceanic areas.
D. continental climatic conditions.
E. the characteristics of man and his artifacts.

50. (1.10) Distinctive fossils or associations of fossils, which make it possible to recognize a formation wherever it occurs and to trace it from its type locality across country are known as index or guide fossils. A good index fossil should have all of the following characteristics *except*

A. abundance. **B.** wide geographic distribution.
C. ease of identification.
D. restricted geological distribution.
E. persistence of its species through several eras.

51. A branch of science primarily interested in the study of
(1.10) plant and animal forms of past geologic eras is

A. petrology. **B.** structural geology.
C. stratigraphy. **D.** paleontology. **E.** archeology.

52. Which one of these represents two immediately successive eras of geologic time?
(1.10)

A. Archeozoic and Paleozoic.
B. Cenozoic and Proterozoic.
C. Cretaceous and Triassic.
D. Mesozoic and Cenozoic.
E. Permian and Cambrian.

53. Sedimentary rocks are *least* important to the geologist
(1.10) for the information they provide concerning

A. the processes involved in their formation.
B. the time at which they were formed.
C. major earth movements occurring after they were formed.
D. deposits of rock extruded from within the earth.
E. environmental conditions existent at the time of formation.

54. The lengths of geologic eras are determined by the time
(1.10) intervals between

A. domination by different animal forms.
B. domination by different plant forms.
C. domination by different plant and animal forms.
D. major breaks in the sedimentary process.
E. sequences in glaciation due to periodic refrigerations.

55. It is believed that man originated in the era known as
(1.10) the

A. Mesozoic. **B.** Proterozoic. **C.** Archeozoic.
D. Cenozoic. **E.** Paleozoic.

56. Man from the time of cave men has occupied the earth
(1.10) only since the recent period of the cenozoic era, whereas the total estimated age of the earth includes five eras. Compared to the total estimated age of the earth, man has occupied it approximately

A. 1/5 of the time. **B.** 1/25 of the time.
C. 1/100 of the time. **D.** 1/100,000 of the time.
E. 1/1,000,000 of the time.

57. The archeozoic and proterozoic records are
(1.10)

A. very largely made up of highly metamorphic rocks and are therefore very hard to reconstruct.
B. first shown in the islands of the mid-Pacific.
C. characterized by sedimentary rocks containing the first clear-cut fossils.
D. very largely made up of volcanic rocks.
E. found only rarely in the earth's surface.

58. Paleozoic exposures are
(1.10)

A. very largely made up of highly metamorphic rocks and are therefore very hard to reconstruct.
B. first shown in the islands of the mid-Pacific.
C. characterized by sedimentary rocks containing the first clear-cut fossils.
D. very largely made up of volcanic rocks.
E. found only rarely in the earth's surface.

59. Some of the geographical implications of fossils are
(1.10)

A. proof of the existence of life in a certain area.
B. usually first developed in metamorphic rock.
C. any fossils which may be demonstrated as belonging to the mollusca.
D. a key to climate or to the existence of natural barriers.
E. used to identify rocks as formed in the same period though widely separated geographically.

60. Guide or index fossils are
(1.10)

A. proof of the existence of life in a certain area.
B. usually first developed in metamorphic rock.
C. any fossils which may be demonstrated as belonging to the mollusca.
D. a key to climate or to the existence of natural barriers.
E. used to identify rocks as formed in the same period though widely separated geographically.

61. A fossil is
(1.10)

A. an organic remains preserved by man.
B. something preserved in rock by heat and pressure.
C. an organic remains of life preserved by natural means.
D. something organic pickled in alcohol.
E. petrifaction as for example in permineralization.

62. One of the means of preserving a fossil is
(1.10)

A. an organic remains preserved by man.
B. something preserved in rock by heat and pressure.
C. an organic remains of life preserved by natural means.
D. something organic pickled in alcohol.
E. petrifaction as for example in permineralization.

63. We may deduce that a tropical climate once prevailed
(1.10) in a region which now has a temperate climate from the study of

A. living plants found in the region.
B. volcanic action. **C.** fossils found in the region.
D. earthquakes.

64. Which one of these mountain ranges probably has the
(1.10) oldest folded structure?

A. Drakensberg. **B.** Appalachian.
C. Norwegian Highlands. **D.** Alps. **E.** Pindus.

65. Three, and only three of the following regions are plains
(1.10) which have been invaded by the sea at various times during the past since stabilization of the shield areas.

a. Belgium. b. Great Plains of the United States.
c. Northwest Siberian Plain. d. Arabia.
e. Finland.

The plains which experienced various marine invasions are

A. a, b, and c. **B.** b, c, and e. **C.** a, b, and e.
D. b, c, and e. **E.** a, d, and e.

66. In the Hanover area which of the following is the oldest
(1.22) in origin?

A. The Sand Hill delta.
B. The high-level meanders of the 460 ft. stage.
C. The high-level deltas of Lake Hitchcock.
D. The till covering the bed rock.
E. The main campus (Hanover Plain).

67. In the Hanover area which of the following is the youngest (most recent) in origin?
(1.22)

A. The high-level (440 ft.) meander terraces.
B. The varves above the subsidence layer.
C. The high-level deltas of Lake Hitchcock.
D. Occom Ridge esker.
E. The low-level deltas of Lake Upham.

68. Which list arranges the organisms in the order of their appearance on the earth first to last?
(1.22)

A. Algae, trilobites, shark, dinosaur, titanotheres.
B. Corals, sharks, trilobites, brachiopods, pelecypods.
C. Amphibians, tree-ferns, algae, grass, horse, elephant.
D. Fusulines, apes, eurypterids, corals, flowering plants.
E. Pelecypods, saber-tooth tigers, shark, elephant, man.

69. Which list below is arranged in correct order with respect to the length of time represented?
(1.22)

(From the longest at top to the shortest at bottom).

1.	2.	3.
Pre-Cambrian	Paleozoic	Ordovician
Paleozoic	Cenozoic	Silurian
Mesozoic	Recent	Devonian
Tertiary	Ordovician	Pleistocene
Quarternary	Pleistocene	Mississippi

70. The main subdivisions of the Tertiary are based upon
(1.23)

A. proportion of mammals to total fossil forms.
B. proportion of still-living marine invertebrates represented among fossil species.
C. percentage of non-marine sediment in the type section.
D. stage of evolution of the horse.
E. the presence of several minor unconformities.

71. Proof that the Green Mts. of Vermont were completely covered by the last ice sheet is substantiated by the following points of evidence, all but one of which is correct. Which one is false?
(1.24)

A. Striae occur on the bed rock on the tops of Green Mts.
B. In some places on the tops of the Green Mts. there are sheep rocks.
C. Rocks found in boulder trains on the east side of the Green Mts. can definitely be traced to their sources on the summits and even to lower ground on the west side of the summits in some cases.
D. Erratics from lower level ledges on the west side of the Green Mts. have been carried to the summits of the mountains and left there when the ice melted.
E. The loess deposits on the summits of the Green Mts. are so thick showing that the ice sheet could not have passed over those summits or it would have eroded almost all of the loess.

72. That there has been considerable warping in the Great Lakes region in recent geologic times is shown by which one of the following statements?
(1.24)

A. The height of the wave cut cliffs in the region of Evanston, Ill.
B. The narrowness of the wave built terraces in the area
C. The elevations of the wave cut beaches along the west shore of Lake Michigan.
D. The currents along the west shore of Lake Michigan are dominantly southward showing that water runs down hill
E. None of the above

73. Which statement best characterizes the Mesozoic?
(1.24)

A. Broad seas covered the western United States at several times during the era.
B. Chief land animals are amphibians.
C. Most important land plants are tree ferns.
D. There were at least three periods of mountain building in the eastern and three in the western U.S.
E. Seas occupied the Appalachian geosyncline during a very short period of the era.

74. The Tertiary history of the Appalachians is characterized by
(1.24)

A. intense folding. **B.** intrusion of salt domes.
C. erosion.
D. uplift, erosion, folding, intrusion of igneous rocks and more erosion.
E. mountain glaciation in higher peaks.

75. Which of the following principles has been most useful in enabling geologists to determine the relative ages of rock strata?
(1.30)

A. Rock strata are normally found in the order of their deposition.
B. In the processes in operation at the present may be found illustrations of most of the changes of the past.
C. In the earth's history, the slow processes such as erosion and sedimentation have had greater influence than catastrophes such as earthquakes and volcanic eruptions.
D. Eras, periods, and epochs indicate definite intervals of development in the earth's history.
E. The uplift and subsequent destruction of one portion of the earth's crust furnishes the material for sedimentary beds being laid down elsewhere.

76. The presence of widespread glaciation in the recent geologic past was postulated because
(1.30)

A. periods of glaciation have always followed periods of diastrophism when the lands stand high as they do now.
B. the glaciers in the Alps and the Cascade Mountains have recently retreated. Thus they must once have extended over more of Europe than they do now.
C. no other known geologic agent can deposit unsorted material, striate and polish boulders and bedrock, and build such topographic forms as moraines.
D. the present rate of erosion is so great that 40,000 years ago the land of North America stood high enough to be above the permanent snow line.
E. astronomical consideration show that it must have been extremely cold during the period between one million years ago and twenty-five thousand years ago.

Item 77 deleted.

78. A certain fossil is easy to identify. It is very abundant and has wide geographic distribution. The organism producing the fossil has not changed significantly since the beginning of the Paleozoic era. This fossil is not a good index fossil because
(1.10)

A. it has wide geographic distribution.
B. the ease with which it can be identified may be misleading.
C. it will appear the same in successive strata.
D. of all of the above reasons.
E. of none of the above reasons.

79. (1.30) A geologist finds a certain species of trilobite in a limestone quarry near Chicago He finds other examples of the same fossil in limestone strata near Niagara Falls and concludes that both limestone formations are of about the same age. This geologist has used the law of

A. uniformitarianism. **B.** superposition.
C. unconformity. **D.** intrusion
E. organic correlation.

80. (1.30) If an igneous intrusion has passed through a layer of sedimentary rock in a series of such layers,

A. the intrusion is probably younger than the layer through which it passed.
B. the intrusion is probably older than the layer through which it passed.
C. a laccolith is formed.
D. a disconformity will probably result.
E. no conclusion can be drawn as to the time sequence of the layer of sedimentary rock through which the intrusion passed and the intrusion.

81. (1.10) In a certain region, a series of sedimentary rock strata has been subjected to extensive folding. Therefore

A. any young valley in the area would be converted to a more mature stage.
B. metamorphic rock is probably present in the area.
C. igneous rock must be present in the form of sills and dikes.
D. the sedimentary rock has been converted by pressure into clay and soil.
E. the land surface is now thoroughly drained by a system of new young valleys.

82. (1.30) Limestone in the Chicago region and the region around Niagara Falls contains similar fossils. It was concluded that the deposits are of similar age since

A. the law of organic correlation applies here.
B. only limestone could contain similar fossils.
C. processes that we can observe elsewhere would account for the climatic changes necessary for fossil deposition.
D. faulting has taken place after the deposition of the limestone.
E. the law of uniform change applies here.

83. (1.30) A geologist concludes that the limestone under Chicago, must have been deposited at the same time as the ledge over which Niagara Falls flows. In reaching this conclusion the geologist has used the law of

A. superposition. **B.** organic correlation.
C. intrusion. **D.** unconformity. **E.** inundation.

84. (1.30) Which of the following laws is most useful in determining that certain strata pertain to one geological era or period, but nearby rocks belong to another era or period?

A. The law of superposition. **B.** The law of intrusion.
C. The law of uniformitarianism.
D. The law of unconformity.

85. (1.30) A geologist finds a certain kind of dinosaur eggs in rock strata in Nebraska and also in rock strata in China. He infers that these widely separated strata are of similar age. This inference is based on the law of

A. superposition. **B.** unconformity.
C. organic correlation. **D.** uniformitarianism.

86. (1.30) A student wanting to determine the oldest rock layers in a diagram of a section of the lithosphere would apply the principle of

A. intrusion. **B.** metamorphism.
C. unconformibility. **D.** rock superposition.
E. fossil ages.

87. (1.30) Utilization of the fossils present in rocks to determine the relative ages of the rocks is dependent upon the theory that

A. the concentration of salt in the oceans is increasing.
B. there has been a gradual increase in the complexity of living forms.
C. the rate of deposition of sediments is to a degree regular.
D. the structure of a rock is dependent upon the environment in which it was formed.
E. unless an organism can adjust to its environment it will become extinct.

88. (1.30) In a series of sedimentary rock layers

A. a layer of limestone always is beneath the layer of sandstone.
B. the most recent layer of the series is sandstone.
C. the most recent layer is the top layer.
D. the layer at the bottom of the series is the most recent layer.
E. nothing can be said about the time sequence of the layers in the series.

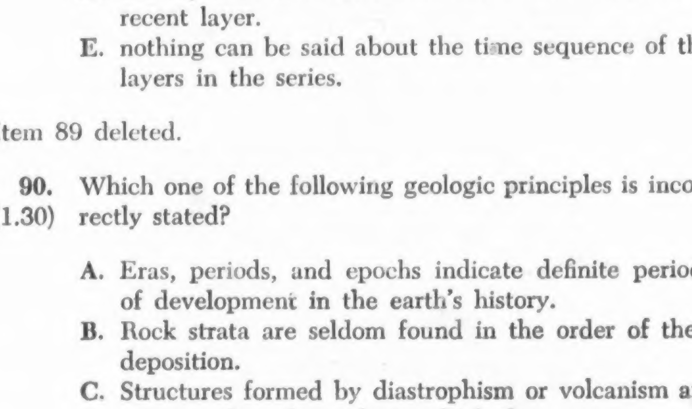
Item 89 deleted.

90. (1.30) Which one of the following geologic principles is incorrectly stated?

A. Eras, periods, and epochs indicate definite periods of development in the earth's history.
B. Rock strata are seldom found in the order of their deposition.
C. Structures formed by diastrophism or volcanism are younger than the rocks in which they occur.
D. Rocks containing the same fossil species are of similar age.
E. Processes which operated to modify the lithosphere in past geologic time were the same as those which are active today.

Items 91 - 103.

In the diagram given below, the letters *A, B, C, D,* and *E,* represent five geological eras. The Azoic Era is not considered. After each item number on the answer sheet blacken the lettered space which designates the era to which the item refers.



91. (2.10) The Mesozoic Era.

93. (2.10) The Archeozoic Era.

92. (2.10) The Proterozoic Era.

94. (2.10) The Cenozoic Era.

95. (2.10) The Paleozoic Era.

96. (1.10) Dinosaur tracks are found in the rocks of this era.

97. (1.10) Trilobites are found in the rocks of this era.

98. (1.10) Probably the shortest of the five eras designated in the diagram by letters.

99. (1.10) The Rocky Mountains were formed at the end of this era.

100. (1.10) Abundant fossils are *first* found in the rocks of this era.

101. (1.10) The great coal deposits were formed during this era.

102. (1.10) Fossils of primitive man are found in deposits of this era.

103. (1.10) The Appalachian Revolution occurred at the end of this era.

Following are three important principles of geology:

1. Geologic processes affecting the lithosphere in the past were the same as those which are active today.
2. Structures produced by diastrophism and volcanism are always younger than the rocks in which they occur.
3. Fossils are evidence of past organic life and sedimentary rocks containing the same fossil species are of similar age.

For each item, 104 - 110, select from the key the most appropriate response.

KEY

A. Based on (1) the statement is true.
B. Based on (2) the statement is true.
C. Based on (3) the statement is true.
D. Based on (1), (2), and/or (3) the statement is false.
E. Nothing is given in (1), (2), or (3) by which the statement can be judged.

104. (2.40) The discovery of ripple marks in ancient sediment indicates that such structures were formed by currents of air or water.

105. (2.40) A basaltic dike truncated by an unconformity would be older than the sedimentary rocks below the unconformity.

106. (2.40) Cambrian sediments in Great Britain do not contain any of the same fossil species as Cambrian rocks in this country.

107. (2.40) Mineralized bones found in certain sedimentary rocks indicate that dinosaurs actually existed on the earth in past geologic times.

108. (2.40) The youngest sedimentary rocks in the Appalachian mountains are older than the mountains themselves.

109. (2.40) The characteristics of the regolith (mantle rock) in Michigan indicates a past episode of glaciation.

110. (2.40) The occurrence of reef corals in some of the limestones of Michigan indicates shallow water marine inundation with tropical climate at some time in the past.

The following list of climatic conditions is to be used in answering the next four questions (numbered 111 through 114). Select the correct answer to these questions and mark the appropriate number on your answer sheet.

A. Alternate wet and dry seasons.
B. Glaciation alternating with warm climates.
C. No sharply defined climatic zones. **D.** Dry.
E. Sharply defined climatic zones.

111. (2.40) Which climate best describes conditions during the Triassic?

112. (2.40) Which best describes conditions during the Recent?

113. (2.40) Which best describes conditions during the Pleistocene?

114. (2.40) Which best describes conditions during the Pennsylvanian?

Items 115 - 118 are based on the following three facts concerning a series of sedimentary rocks making up a cliff.

1. The series is represented by an under clay, above which lies a thick coal seam. On top of the coal is a limestone bed.
2. The sediments have not been overturned. (They are as originally deposited.)
3. A normal fault cuts the strata.

For each item select from the key the most appropriate response.

KEY

A. Based on (1) the statement is true.
B. Based on (2) the statement is true.
C. Based on (3) the statement is true.
D. Based on statements (1), (2), and/or (3) the statement is false.
E. No evidence is given in (1), (2), or (3) by which this statement can be judged.

115. (2.40) The region was subjected to horizontal tensional forces.

116. (2.40) The climate during part of the time of deposition was warm.

117. (2.40) Differential movement of the crustal blocks occurred at some time after deposition.

118. (2.40) The lowest bed of the series is the youngest.

119. (3.00) "How could a scientist determine whether or not all events at present are occurring at twice the rate as in the past?" Which of the following statements best answers the question?

A. Clocks operating at one-half the present speed could be used to compare phenomena.
B. Observations on pendulums would show whether they oscillate more rapidly now.
C. The question is not capable of experimental investigation, all instruments would have been affected identically.
D. The life cycles of organisms would show a slight but definite shortening.
E. Recent geological strata could be compared as to thickness with older strata.

120. (3.00) Which of the following constitute conclusive evidence that the earth has been shrinking?

A. Necessary deduction from the theory that the earth was formed by condensation of gas pulled from the sun.
B. The existence of folded mountain ranges which were formed at many times in the geological past, and in many parts of the earth.
C. The earth is now radiating heat at the rate of 2×10^{-6} cal/sec/cm.
D. Astronomical data has shown that the moon is slowly receding from the earth.
E. None of the above.

121. (2.40) Some geologists subscribe to the hypothesis that the earth has been shrinking. Which of the following is the best evidence for this hypothesis?

A. The earth is not a perfect sphere.
B. The density of the interior of the earth is considerably higher than that of the surface layers.
C. The force of gravity varies in different parts of the earth.
D. The earth came originally from the sun as heterogeneous material and has been readjusting to the force of gravity.
E. Mountain ranges consist of series of folds.

Items 122 - 123.

A simple idea, conveyed by the phrase "order of superposition," is an essential part of the principle of dating by fossils. Consider the great section of marine sedimentary rocks in the walls of the outer gorge of the Grand Canyon of the Colorado River. In every formation of that series are some fossil species which are limited to it. In New York, or in Tennessee, or in dozens of other places in the country, are strata containing fossils peculiar to each of these Grand Canyon formations. They are therefore of the same age. The principle applies to the entire world. We correlate stratified rocks of Australia, or Asia, with those of North America on the basis of the contained date-marking fossils.

In the Grand Canyon, downstream from the inner or granite gorge, sedimentary rocks constitute the entire exposed section. But only in the upper half of the wall are the strata horizontal. A definite dividing line can be drawn between horizontal beds above and tilted (and faulted) beds below. This line of contact is an unconformity. It is a record of diastrophism that can be dated. This diastrophism was an interruption in the sedimentation recorded in the canyon wall. The unconformity is also a record of erosion after the diastrophism but before the deposition of the overlying strata.

122. (2.10) The simple idea conveyed by the phrase "order of superposition" is

A. dikes are younger than the beds they cut through; therefore the upper part of a dike is younger than the sediments which are near its base.
B. in a series of sedimentary beds the succession from bottom to top is one of age as well as of position.
C. in a series of rock masses of any sort the rocks at greater elevations are the younger.
D. a sill-type of intrusion is younger than any sedimentary bed beneath it.
E. all sedimentary beds are laid down by natural processes observable today.

123. (4.10) In describing certain fossils as "date-marking" the writer apparently assumes:

A. The time of deposition of a bed was the "species life span" of the organisms which are confined to it.
B. All species of fossils represent extinct forms of life.
C. These forms of life were peculiar to the Grand Canyon region.
D. No species of fossils spans more than one formation.
E. Only those beds which contain a given fossil were deposited at the same time.

Items 124 - 129.

One of the methods formerly used by geologists to determine the age of the earth was a calculation based on the amount of salt (NaCl) in the ocean, and the amount added to ocean waters each year by the rivers. If this method of age determination is used, certain assumptions must be made. Below are listed a number of assumptions which are to be judged according to the following key.

KEY

A. The assumption is necessary for the calculation and most probably true.
B. The assumption is necessary for the calculation but most probably false.
C. The assumption is not necessary for the calculation but is probably true.
D. The assumption is not necessary for the calculation and is probably false.

124. (4.10) Oceans have been on the earth since our planet was formed.

125. (4.10) Ever since its origin the earth has revolved around the sun.

126. (4.10) The ocean contains all the salt which has ever been added to it.

127. (4.10) The salt which rivers have carried to the ocean all occurred in mineral form in the rocks before it was dissolved by the river waters.

128. (4.10) The proportion of the lithosphere existing above the ocean waters has been constant through the geologic ages.

129. (4.10) The continental masses have existed in essentially their present outline since the formation of the earth.

130. (4.10) In calculating the age of the oceans it is assumed that the concentration of dissolved salts in the oceans

A. results mainly from solution of salt found on the deep sea floor.
B. results mainly from salt carried to the sea by rivers.
C. results mainly from decomposition of animals and plants in the sea.
D. was greatest when the oceans were born.

131. (4.10) The story of the mammals

A. is true because nature writes its history as plain as any history recorded on a printed page.
B. is a theory bolstered by evidence uncovered in the bone beds of America's west.
C. is a mere guess presented by people who are believers in the theory of evolution.
D. is true because it is accepted by most educated people.

132. (4.10) The story of the mammals differs from other chapters of evolutionary history only in that it has not yet ended.

The statement

A. is a verified conclusion. **B.** is an assumption.
C. is neither in agreement or disagreement with the scientific point of view.
D. is an hypothesis.

133. (4.10) During 100 million years of the mesozoic era when dinosaurs ruled the earth—

Directions: Check the item that is the best answer.

A. An opinion based on evidence. **B.** A fact.
C. A statement that is unwarranted. **D.** A guess.

134. (2.14 or 1.23) A group of small timorous creatures dwelt in the shadows of the marsh lands and sought safety in the higher branches of the soft wood forests.

Directions: check the item that gives the correct completion of the sentence.

The statement is based on

A. cause and effect reasoning.
B. relativity of theory and concept.
C. extension of data. **D.** teleological reasoning.

Items 135 - 142 deleted.

13. Force, Motion, Gravitation

FORCE, MOTION, GRAVITATION

After each item number (items 1 - 13) on the answer sheet, blacken the *one* lettered space which designates the word or phrase that would correctly complete the item.

A. Zero. **B.** Constant, but not zero.
C. Increasing at a constant rate.
D. Decreasing at a constant rate.

1. (1.10) The acceleration of a freely falling body is

2. (1.10) The velocity of a freely falling body is

3. (1.10) The force acting on a freely falling body is

4. (1.10) The acceleration of a car traveling south at a continuous rate of 30 miles per hour is

5. (1.20) The acceleration of a car, stopping for a red light at the rate of 5 feet per second is

6. (1.20) The velocity of a car moving with an acceleration of 11 feet per second per second is

7. (1.10) The velocity of a car, coasting after the motor has been shut off, is

8. (1.10) The velocity of a car, when the push of the motor just equals the frictional forces tending to stop the car, is

9. (1.20) The acceleration of a cable car being towed up an incline by a motor which turns the cable drum 50 revolutions per minute is

10. (1.20) If an object is moving in a given direction at a constant velocity and there is no friction or air resistance, the force is

11. (1.20) If the velocity of the object referred to in item 10 is increasing at a constant rate, the acceleration is

12. (1.20) If the velocity of the object referred to in item 10 is increasing at a constant rate, the force is

13. (1.20) If the acceleration of the object referred to in item 10 is increasing at a constant rate, the force is

14. (1.10) Which one of these has the smallest weight?

A. Neutron. **B.** Electron. **C.** Ion. **D.** Proton.
E. Atom.

15. (1.10) The best explanation for the nearly spherical shape of raindrops is based on

A. evaporation. **B.** gravity. **C.** capillary action.
D. surface tension. **E.** the Brownian movement.

16. (1.10) During protracted dry spells, deep-rooted plants may obtain a limited supply of water from the fringe immediately above the water table. This water is obtained directly from the ground water supply and moves upward against the force of gravity because of

A. cohesive force. **B.** viscosity.
C. capillary action. **D.** Pascal's principle.
E. Bernoulli's principle.

17. (1.10) The change of distance per unit of time without reference to direction is called

A. velocity. **B.** speed. **C.** inertia.
D. acceleration. **E.** distance.

18. (1.10) The fundamental units of measure are

A. speed, time and distance.
B. length, width and area.
C. length, mass and time. **D.** area, heat and volume.
E. millimeter, centimeter and kilometer.

19. (1.10) When an object falls freely in a vacuum

A. the velocity cannot become greater than 32 feet/second.
B. the acceleration decreases until the terminal velocity is attained.
C. the acceleration is constant.
D. the acceleration constantly increases.
E. the acceleration is zero.

20. (1.10) A millibar is a unit of

A. work. **B.** force. **C.** energy. **D.** distance.
E. pressure.

21. (1.10) Accelerations are *never* expressed as

A. miles per hour per second.
B. meters per second squared.
C. feet per second. **D.** cm./sec.^{2}
E. the time rate of change of velocity.

22. (1.10) Which one of the following statements is correct for a freely falling body?

A. The average velocity during the first second is 16 ft. per sec.
B. During each second the body falls 32 feet.
C. The acceleration changes by 32 feet, every second.
D. The body falls 32 feet during the first second.
E. The acceleration depends upon the weight of the body.

23. (1.10) Generous quantities of mercury, water, and engine oil are poured into a tall glass cylinder, after which a glass marble is dropped in. Which one of the following is an *incorrect* statement?

A. The mercury will be at the bottom of the cylinder.
B. The oil will float on the water.
C. The water will float on the mercury.
D. The marble will float on the oil.
E. The marble will be partially submerged in the mercury.

24. (1.10) Which one of the following ratios defines acceleration?

A. Distance/time. **B.** Mass/force.
C. Resistance/effort. **D.** Velocity/time.
E. Mass/velocity.

25. (1.10) Which one of these *includes* all the others?

A. Cohesion. **B.** Force. **C.** Surface tension.
D. Gravity. **E.** Adhesion.

26. (1.10) Compared to its weight in air a body when weighed in a vacuum

B. weighs more. **B.** weighs slightly less.
C. weighs the same as in air.
E. loses all of its weight.

Items 27 - 33 refer to various units of physical measurement in the metric system which have their counterparts in the English system of units. For each item select from the key the analogous unit or concept involved.

KEY

A. Poundal. **B.** Foot-pound per second.
C. Foot-pound. **D.** Cubic inches.
E. Pounds per cubic foot.

27. (1.10) Joules. **28.** (1.10) Liters. **29.** (1.10) Watts.

30. (1.10) Dynes. **31.** (1.10) Ergs.

32. (1.10) Kilogram-meters. **33.** (1.10) Gm./cm. 3.

34. (1.10) Which one of the following statements is correct?

A. One pound mass weighs one poundal.
B. One gram mass weights one dyne.
C. One poundal weighs 980 pounds.
D. One gram mass weighs 980 dynes.
E. One poundal weighs 32 pounds.

35. (1.10) Which one of these is *not* an illustration of simple harmonic motion?

A. A vibrating tuning fork.
B. A swinging pendulum.
C. A stone whirled on the end of a string.
D. The motion of a particle in a transverse wave.
E. The vibration of a weighted spring.

36. (1.10) The force, equal in magnitude to the vector sum of two or more forces, but oppositely directed is the

A. component. **B.** resultant. **C.** hypotenuse.
D. centrifugal reaction. **E.** equilibrant.

37. (1.10) Which one of these terms involves all the others?

A. Gravity. **B.** Force. **C.** The spring constant.
D. Surface tension. **E.** Molecular attraction.

38. (1.10) A unit corresponding to the dyne in the English system is the

A. pound. **B.** poundal. **C.** foot pound.
D. ounce. **E.** none of these.

39. (1.10) The specific gravity of a liquid may be measured directly by means of a

A. burette. **B.** psychrometer. **C.** barometer.
D. hydrometer. **E.** hygrometer.

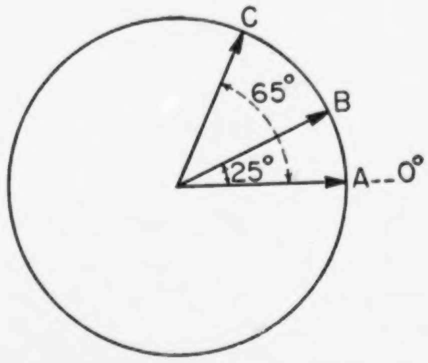
Item 40. Evaluate the statements according to the key.

KEY

A. The statement is true under any and all conditions.
B. The statement is true under nearly but not all conditions.
C. The statement is false under all conditions.
D. The statement is false under nearly but not all conditions.
E. It is impossible to prove any marked degree of truth or falsity.

40. (1.10) I. A body falling freely through the atmosphere approaches the earth at an ever increasing velocity.

40. (1.10) II. More useful energy is put into all machines than is gotten out.



41. (1.10) A student using a force table to test his numerical answer of 100 gms. for the resultant of three forces, A, B, and C, correctly placed A at 0°, B at 25°, and C at 65° as indicated in the diagram. The answer of 100 gm. made an angle of 20° with the force A.

A proper use of the force table for experimentally testing the accuracy of the answer of 100 gm., requires that the 100 gm. be placed on the force table at

A. 20°. **B.** 180°. **C.** 200°. **D.** 205°. **E.** 32½°.

42. (1.10) An acceleration could be measured in any of the following ways *except*

A. miles per hour per second.
B. meters per second squared.
C. as the time rate of change of velocity.
D. feet per second. **E.** centimeters per day per day.

Items 43 - 45. True or False.

43. (1.10) Speed and velocity have the same meaning.

44. (1.10) Concurrent forces pass through a common point.

45. (1.10) 88 feet per second is 60 miles per hours.

46. (1.10) In the free-fall experiment, the acceleration of the falling bob

A. increased. **B.** decreased. **C.** remained constant.
D. increased first, then decreased.
E. could not be determined.

Items 47 - 56: For each item mark space

A. if the entity described on the left *is greater than* that on the right.
B. if the entity described on the left *is less than* that on the right.
C. if the left and right are *essentially the same* in magnitude.

48. (1.10)	The velocity of a freely falling body of *3 grams* after 10 seconds is	**A.** greater than **B.** less than **C.** the same as	the velocity of a freely falling body of *6 grams* after 10 seconds.
49. (1.10)	The acceleration of a freely falling body of 3 grams after *3 seconds* is	**A.** greater than **B.** less than **C.** the same as	the acceleration of a freely falling body of 3 grams after *6 seconds*.

50. (2.40)	The force of gravitation between the earth and an object of 10 grams 5 *feet* from the earth's surface is	**A.** greater than **B.** less than **C.** the same as	the force of gravitation between the earth and an object of 10 grams *5000 feet* from the earth's surface.
51. (2.40)	The force of gravitation between the earth and an object of *10 grams* 5 feet from the earth's surface is	**A.** greater than **B.** less than **C.** the same as	the force of gravitation between the earth and an object of *5000 grams* 5 feet from the earth's surface.
52. (1.20)	The force on the *rear of the cartridge* when the cartridge is fired in a .22 calibre rifle is	**A.** greater than **B.** less than **C.** the same as	the force on the *lead bullet* when the cartridge is fired in a .22 calibre rifle.
53. (1.10)	The inertia of a 5-pound ball *at rest* is	**A.** greater than **B.** less than **C.** the same as	the inertia of a 5-pound ball *in motion.*
54. (1.22)	The number of glucose molecules consumed in respiration when one gram of starch is oxidized in the body is	**A.** greater than **B.** less than **C.** the same as	the number of *carbon dioxide* molecules released during the oxidation of the same gram of starch.
55. (1.22)	The number of *free oxygen* molecules liberated to the atmosphere when one molecule of glucose is produced in photosynthesis is	**A.** greater than **B.** less than **C.** the same as	the number of *carbon dioxide* molecules entering the reaction when one molecule of glucose is produced in photosynthesis.
56. (1.22)	The extent to which a ray of light is bent when it enters plate glass at an angle from the air is	**A.** greater than **B.** less than **C.** the same as	the extent to which the ray of light is bent as it *leaves* the plate glass and again travels through the air.
57. (1.10)	The velocity of light in *air* is	**A.** greater than **B.** less than **C.** the same as	the velocity of light in *water.*

58. (1.10) The gravitational pull of the earth determines the

A. weight of a body.
B. atomic energy of a body. **C.** density of a body.
D. state of a body. **E.** mass of a body.

59. (1.10) Which term is not related to the others?

A. Vector. **B.** Resultant. **C.** Component.
D. Exponent. **E.** Equilibrant.

60. (1.10) Which one of these is a vector quantity?

A. Length times width. **B.** Speed. **C.** Energy.
D. Moment of inertia. **E.** Directed force.

61. (1.10) Which one of these is a vector quantity?

A. Uniform speed around a circle. **B.** Density.
C. Speed. **D.** Length times width. **E.** Volume.

62. (1.10) Which one of these is a scalar quantity?

A. A velocity of 30 mi./hr.
B. A pull on a sled at an angle of 20°.
C. A mass of 10 lbs.
D. A force of attraction by a plus charge on a minus charge which is east of it.
E. A N wind of 15 mi./hr.

63. (1.10) That force which is numerically equal to the effective sum of two or more directed forces but oppositely directed is known as the

A. resultant. **B.** equilibrant. **C.** component.
D. hypotenuse. **E.** centrifugal reaction.

64. (1.10) The weight of a given body depends upon

A. its shape. **B.** its volume.
C. the gravitational pull of the earth.
D. whether it is a solid, a liquid or a gas.
E. whether it is hot or cold.

65. (1.10) The poundal is the absolute unit of

A. force. **B.** work. **C.** power. **D.** inertia.
E. acceleration.

66. (1.10) F = M a. When M is in grams and a is in cms./sec.^{2}, F is in

A. dynes. **B.** poundals. **C.** grams. **D.** joules.
E. ergs.

67. (1.10) The average speed of a moving object during a given interval of time is always

A. its speed at any point.
B. the distance covered during the interval divided by the time.
C. one-half its speed at the end of the interval.
D. its acceleration multiplied by the time.
E. one-half its acceleration multiplied by the time.

68. (1.10) A vector quantity is by definition

A. a quantity having both direction and magnitude.
B. a force.
C. applicable only to a body which is not in motion.
D. an arrow dependent on an arbitrary scale.
E. applicable only to a body which is in motion.

69. (1.10) A body is in stable equilibrium only if

A. its center of gravity is as low as possible.
B. its center of gravity is beneath its support.
C. any slight tipping raises its center of gravity.
D. its base is flat. **E.** it cannot be moved.

70. (1.10) By the term "acceleration" we mean

A. the change in velocity in one unit of time.
B. one-half the average velocity.
C. the increase (or decrease) in the distance covered.
D. the speed of a falling body.
E. the total change in velocity.

71. (1.10) Among the physical quantities which require the inclusion of a statement of direction to be completely specified is

A. mass. **B.** volume. **C.** energy. **D.** time.
E. acceleration.

72. (1.10) The center of gravity of a body

- **A.** is the point of application of the resultant of all the gravitational forces exerted on the particles of the body.
- **B.** can be found only for a regularly shaped body.
- **C.** is always located within the material of the body.
- **D.** depends upon the position relative to the center of the earth.

73. (1.10) A moment of force

- **A.** is the product of force and speed.
- **B.** is the same as power. **C.** is the same as work.
- **D.** can be balanced by another moment of force.
- **E.** cannot be balanced by another moment of force.

74. (1.10) The inertia of a body tends to cause the body

- **A.** to speed up. **B.** to slow down.
- **C.** to resist any change in its motion.
- **D.** to fall to the surface of the earth.

75. (1.10) The "weight" of a body is

- **A.** simply another term for its "mass." **B.** a constant.
- **C.** determined by means of a beam balance.
- **D.** dependent on the locality in which it is determined.
- **E.** always expressed in pounds.

76. (1.10) In Archimedes' postulate, the parts of fluids which "lie evenly" are

- **A.** in such positions that they can thrust one another.
- **B.** along the same radius from the center of the earth.
- **C.** at rest with respect to the other parts of fluids.
- **D.** at the same distance from the center of the earth.
- **E.** in such positions that they are immovable.

True or False.

77. (1.21) Concurrent forces may be represented by vectors.

For each item, 78 - 87, blacken the one numbered space which designates the word or phrase in the key below that would correctly complete the statement.

KEY

- **A.** Zero, or continuously zero.
- **B.** Continuously a constant amount not zero.
- **C.** Zero, then a constant amount greater than zero, then zero again.
- **D.** Continuously variable in amount.

(Assume no air resistance and no friction unless otherwise indicated.)

78. (1.22) If a car is moving along a straight road at constant speed, the force is

79. (1.22) If the acceleration of a car is increasing, the force acting on the car is

80. (1.22) The acceleration of a car is constant if the force acting is

81. (1.22) A car traveling for a time at 20 miles an hour along a straight road later increases its speed uniformly to 30 miles per hour, at which speed it moves for some time. The force is

82. (1.22) Equal distances along a straight line are traversed by a moving object in equal times if the force acting on the object is

83. (1.22) A uniformly changing speed along a straight line is produced by a force which is

84. (1.22) A body is falling because of gravity, but air resistance is no longer negligible. Until the body reaches its "terminal velocity," the speed is

85. (1.22) After the "terminal velocity" has been reached, the net force on the body is

86. (1.22) After the body reaches its "terminal velocity," the acceleration is

87. (1.22) Until the "terminal velocity" is reached, the distance covered in successive seconds is

88. (1.22) A student recorded the following observations in connection with an experimental determination of the specific gravity of a liquid. All of the following observations are essential for this determination except:

- **A.** All of the following are essential.
- **B.** Weight in air of metal cylinder–48 g.
- **C.** Weight in water of metal cylinder–24 g.
- **D.** Weight in unknown liquid of metal cylinder–36 g.

89. (1.22) An essential observation that the student failed to record involves

- **A.** no essential information was omitted.
- **B.** the volume of the cylinder.
- **C.** the volume of liquid in the unknown sample.
- **D.** the specific gravity of the metal cylinder.
- **E.** the weight of the sample of unknown liquid.

90. (1.22) A bullet shot from a gun held in a horizontal position

- **A.** strikes the ground much later than one dropped vertically from the same point at the same instant.
- **B.** is stopped by air resistance alone.
- **C.** strikes the ground at approximately the same time as one dropped vertically from the same point at the same instant.
- **D.** travels in a straight path.
- **E.** strikes the ground much sooner than one dropped vertically from the same point at the same instant.

91. (1.22) Which of the following phenomena *cannot* be explained without using both of the concepts of adhesive force and cohesive force?

A. Vapor pressure. **B.** Viscosity.
C. Surface tension. **D.** Capillarity. **E.** Osmosis.

92. (1.22) In comparing the *speed* with which a baseball thrown horizontally leaves the thrower's arm to the *time* elapsing before the ball strikes the ground, it may be stated that

- **A.** doubling the speed will double the time.
- **B.** doubling the speed will halve the time.
- **C.** doubling the speed will increase the time by four times.
- **D.** doubling the speed will reduce the time to one quarter of its original value.
- **E.** doubling the speed will have no effect on the time.

93. (1.22) The air was carefully pressed out of a flat paper sack and the sack was weighed. The sack was then opened as wide as possible and again weighed. Finally the top of the opened sack was twisted shut so that it was filled with air at atmospheric pressure and it was again weighed. The relationship between these weights was

A. first equals the second, equals the third.
B. first less than the second, equals the third.
C. first less than the second, less than the third.
D. first equals the second, less than the third.
E. dependent upon the size of the sack.

94. (1.22) Since Galileo's famous experiments, man has accepted the fact that a large stone falls no faster than a small one. Which one of the following is incorrect?

A. A large stone may have the same mass as a small one.
B. The ratio of force to mass is the same for both stones.
C. The attractive force of the earth is the same on both stones regardless of their masses.
D. Disregarding air friction, the acceleration due to gravity is the same for both.
E If the stones were of equal mass, their inertia would be the same.

95. (1.22) Pilots often argue that a fast airplane will drift less than a slow plane of the same weight and design when a wind acts at right angles *on both for a given length of time.*

This statement is

A. true because the resultant of the forward motion of the plane and of the force of the wind is greater in the case of the fast plane.
B. false because there is an equal and opposite reaction to every action.
C. true because the faster airplane is able to offset the drift by its faster motion.
D. false because the drift is independent of and unaffected by the forward motion.
E. true because a pilot can fly between two cities in the faster plane with less correction for drift than in the slow plane.

96. (1.22) Neglecting air friction, a ball thrown horizontally at the same time a similar ball is released vertically will show that

A. vertical and horizontal motions are dependent upon each other.
B. both have the same velocity at the end of the flight.
C. both travel equal distances.
D. both have equal times of flight.
E. the ball thrown horizontally takes longer to reach the ground.

97. (1.22) Disregarding air friction it has been established that a ball thrown horizontally reaches the ground at the same time as a similar ball dropped vertically from the same height. The best explanation of this is

A. celestial and terrestrial mechanics favor curved motion.
B. the horizontal component of gravity increases the velocity of the ball moving horizontally.
C. inertia.
D. the force of gravity acts independently of the horizontal force.
E. the horizontal force originally acting on the ball imparts partial vertical velocity to the ball.

98. (1.22) Disregarding air friction, a ball thrown horizontally reaches the ground at the same time as a similar ball released to fall vertically from the same height. The best explanation of this is that

A. it is easier for an object to follow a curved path even though it is longer.
B. the force of gravity acts independently of the horizontal force.
C. a body in motion tends to continue in motion until stopped by an external force.
D. the horizontal component of gravity increases the velocity of the thrown ball.
E. the force of gravity added to the horizontal force makes the thrown ball cover its path more rapidly.

99. (1.22) If a baseball is thrown straight upward, at the top of its flight

A. its potential energy is equal to one-half of its kinetic energy.
B. it possesses no energy.
C. its potential energy will be at a minimum while its kinetic energy will be maximum.
D. it will possess no potential energy and one-half of its kinetic energy.
E. it will possess no kinetic energy and its maximum potential energy.

100. (1.22) A bomber flying in level flight 180 miles per hour (264 ft. per sec.) at a height of 14,400 feet, must release the bomb before it is over the target. Neglecting air resistance, which one of the following statements is not true?

A. The bomber will be over the target when the bomb strikes.
B. The horizontal and vertical forces acting on the bomb are independent.
C. The horizontal velocity of the plane and the vertical velocity of the bomb will be equal when the target is reached.
D. the forward moving bomb will travel in a curved path.
E. The time of flight of the bomb would have been the same if the plane could have stood still when the bomb was dropped.

101. (1.22) A bomber flying in level flight at 300 miles per hour and at an altitude of 15,000 feet, must release the bomb before it is over the target. Neglecting air resistance, which one of the following statements is not true?

A. The bomber will be over the target when the bomb strikes.
B. The horizontal and vertical forces acting on the bomb are independent.
C. The resultant velocity of the plane and the bomb will be the same when the target is reached.
D. The force of gravity will cause the forwarding bomb to travel in a curved path.
E. The time of flight of the bomb would have been the same if the plane could have stood still when the bomb was dropped.

102. (1.22) Which one of these is true about the bomb in the preceding item?

A. At the half-way mark after release, the bomb has both kinetic and potential energy.
B. The kinetic energy before the bomb is released is zero.

C. Just before impact, the bomb has its greatest potential energy.
D. The chemical energy of the bomb furnishes it with kinetic energy in flight.
E. All of the energy of the bomb is potential before it is dropped.

103. (1.22) A 150-pound object is dropped from an airplane in level flight moving at a speed of 180 miles per hour (264 feet per second). The plane is headed due north but is being acted upon by an east wind of 20 mph (29.3 feet per second). The essential information to determine how far the object will fall in three seconds is

A. the weight of the object.
B. the actual speed and direction of the plane.
C. the fact that the plane is in level flight.
D. the actual speed of the plane.
E. none of these is necessary.

104. (1.22) If it were possible to have a body in motion with a velocity of 10 ft. per sec. along a frictionless level surface, the acceleration (without air resistance)

A. would decrease.
B. would be constant but not zero.
C. would be zero.
D. would be unknown without additional data.
E. would increase.

105. (1.22) Which of the following factors has *least* to do with determining the height a liquid will rise in a small diameter tube?

A. The force of gravity.
B. The angle between the surface of the liquid and the walls of the tube.
C. The radius of the tube.
D. The density of the liquid.
E. Atmospheric pressure.

106. (1.22) If the velocity of a body increases, it is certain that during the time of this increase

A. the density of the body increases.
B. the acceleration of the body increases.
D. the body is accelerated.
D. the acceleration of the body is constant.

107. (1.22) Why do raindrops fall with constant speed during the later stages of their descent?

A. The gravitational force exerted on any one drop is equal to the gravitational force exerted on any other drop.
B. The air resistance just balances the force of gravity.
C. The drops all start from the same height.
D. The force of gravity is negligible for objects as small as raindrops.
E. Gravitation cannot increase the speed of a falling body to more than 32 ft./sec.

108. (1.22) Why doesn't a 5 lb. mass fall 5 times as fast as a 1 lb. mass of the same size and shape?

A. Air friction has more effect on the 5 lb. mass.
B. The ratio of force to mass is the same for both.
C. The earth's attractive force is the same for both.
D. If two unequal objects have the same kinetic energy, the lighter moves more rapidly.
E. A 5 lb. mass and a 1 lb. mass are observed to fall at the same rate in vacuum.

109. (1.22) A 10 lb. mass does not fall four times as fast as a 2½ lb. mass because

A. the attractive force of the earth is the same on both.
B. air friction is greater on the larger mass.
C. the ratio of force to mass is the same for each.
D. the density of the larger mass may be four times as great as the smaller so that each has the same volume.
E. of none of the above.

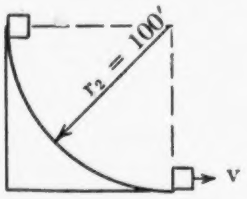
110. (1.22) It is easier to skate on ice than to slide on your shoes, largely because

A. steel is smoother than leather.
B. skates exert a much greater force.
C. leather, a poor conductor of heat, tends to melt the ice.
D. the skates are colder than leather.
E. when on skates the force acts on a very small area.

111. (1.22) A 200 pound body is thrown horizontally at a uniform velocity of 88 feet per second. It strikes a wall and displaces it 3 inches in 0.01 second. With this data, it is possible to calculate all of the following quantities *except*

A. the potential energy possessed by the body.
B. the force with which the body strikes the wall.
C. the work accomplished in moving the wall.
D. the power expenditure of the body following impact.
E. the average acceleration of the body following impact.

112. (1.20) A body slides from rest without friction down a track consisting of one quadrant of a circle of radius 100 ft. What is the magnitude of the velocity at the bottom?



A. 100 ft./sec. **B.** 80 ft./sec. **C.** 64 ft./sec.
D. None of the first three choices.
E. There is not enough information given to compute the velocity.

Items 113 - 117. After the answer sheet number corresponding to that of each of the following paired items, blacken space

A. if the item at the left is greater than the item at the right.
B. if the item at the right is greater than the item at the left.
C. if the two items are of the same magnitude.

113. (1.22)	The gravitational pull of the earth upon a man on the earth's surface.	....	The gravitational pull of the moon upon the same man on the moon's surface.
114. (1.22)	The force needed to accelerate a car on a horizontal track on the moon.	....	The force needed to equally accelerate the same car on a horizontal track on the moon.
115. (1.22)	The gravitational pull of the sun for the earth in July.	....	The gravitational pull of the sun for the earth in January.

116. (1.22) The attraction of the earth for a meteor at a distance of 8000 miles. .... The attraction of the earth for a meteor at a distance of 800 miles.

117. (1.22) The ocean tides when the sun, the earth and the moon are in alignment as (S ME). .... The ocean tides when sun and moon form a right angle with the earth as (S E).
M

118. (1.22) The apparent weight of a body is influenced in some degree by all of these *except*

A. gravity.
B. the distance from the center of the earth.
C. centrifugal force. **D.** mass. **E.** the atmosphere.

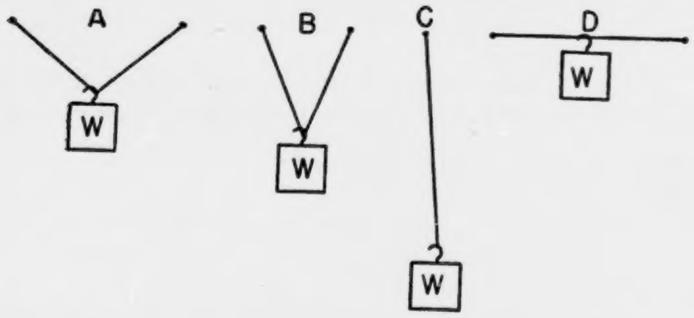
119. (1.22) When a number of forces are acting on a point so that the point is in equilibrium, which one of the following statements is *incorrect?*

A. The point may be in motion at uniform speed.
B. An equilibrant may be acting to hold it stationary.
C. The resultant of all the forces is zero.
D. The point may be stationary. **E.** None.

True or False.

120. (1.22) A 150 pound man may produce a ton or more of force in a rope.

121. (1.22) Assume the strings in the diagram below to be of equal length and the weights of equal value. The greatest strain tending to break the string is produced in arrangement



A. A. **B.** B. **C.** C. **D.** D.
E. The strain is equal in all.

True or False.

122. (1.22) All freely falling bodies have the same acceleration.

123. (1.22) Neglecting friction of the air, a baseball thrown horizontally at the same time a similar ball is released to fall vertically will show

A. unequal times of flight.
B. equal distances traveled.
C. the same velocity at the end of the flight.
D. that the horizontal and vertical forces are independent.
E. that gravity has a component horizontally.

124. (1.22) A force of 10 lb. and another of 12 lb. may be applied so that their resultant can be

A. 0 lb. **B.** 1 lb. **C.** 10 lb. **D.** 24 lb.
E. 120 lb.

Item 125 deleted.

126. (1.22) The period of a simple pendulum swinging through a small angle is independent of

A. the acceleration of gravity.
B. the height above sea level.
C. the material in the bob.
D. the length of the pendulum. **E.** none of these.

127. (1.22) If the motor, flywheel, and propeller of a single-engined plane is turning clockwise, from the pilot's viewpoint, while flying a straight course, when he makes a sudden right turn, gyroscopic action will cause the plane to

A. nose up. **B.** spin on a vertical axis.
C. restore its straight course.
D. experience no effect. **E.** nose down.

128. (1.22a) The amount of weight which must be added to one pan of a beam balance to cause the pointer to move one scale division always depends upon

A. the load in the pans.
B. the position of the center of gravity of the beam with relation to the knife edge.
C. the angle through which the pointer is swinging.
D. the barometic pressure at the time of weighing.
E. the density of the material of which the weights are made.

129. (1.22a) If the diameter of the earth were twice its present value while the mass remained the same, the weight of an object on the earth's surface would be

A. twice its present value.
B. one-half its present value.
C. the same as its present value.
D. one-fourth its present value.
E. four times its present value.

130. (1.22a) The rise of a liquid in a narrow capillary tube whose walls it wets is

A. proportional to the radius of the tube.
B. inversely proportional to the density of the liquid.
C. inversely proportional to the surface tension of the liquid.
D. independent of the density of the liquid.
E. proportional to the length of the tube.

131. (1.22a) Which of these determines the pressure in a liquid in an open container?

A. The shape of the container and the area of its base.
B. The depth of the liquid and its density.
C. The viscosity of the liquid.
D. The depth of the liquid and the shape of the container.

132. (1.23) A vector quantity may be distinguished from a scalar because it has

A. constant properties. **B.** direction.
C. magnitude. **D.** force. **E.** length.

133. (1.24) A steel ball will fall with constant speed in air

A. if the force of air friction is equal to "g."
B. if the resultant force on the ball has a constant value other than zero.
C. if the force of gravitation is equal in magnitude to the force of air friction.
D. if the force of gravitation is exceeded by the kinetic energy of the ball.
E. under none of these conditions; the acceleration will be equal to "g."

134. By means of a beam balance as ordinarily used, we
(1.25)

A. detect variations in the value of the force of gravity.
B. eliminate the effect of the buoyant force of air in weighing.
C. compare masses.
D. eliminate the necessity of having standards of mass.
E. measure the same quantity as by means of a spring balance.

Items 135 - 139 are concerned with the following paragraph.

Read the following selection carefully.

A number of science fiction stories, comic strips and motion pictures have dealt with possible future space travel. The situations depicted are not necessarily impossible. The military authorities and planners of various countries, including our own, are giving serious consideration to the possibilities of space travel, and are studying the problems involved. Some of these problems have to do with the effects on the human body of the accelerations which it is necessary to attain in order to leave the earth. Others are concerned with the conditions in interplanetary space, and the kinds of ships and equipment which it would be necessary to build in order to travel or exist there. These problems are well-known to writers of science fiction. To make their stories as near to reality as possible they have to take these problems into consideration. Therefore, all such stories have certain principles in common. The following items are based on these common principles.

Directions: For items 135 - 139 select the best answer and mark the corresponding space on the answer sheet to the right of the item number.

135. Space suits are usually shown as equipped with heavy
(1.30) shoes having thick magnetic soles. These serve to

A. hold the feet downward and the body in an upright position.
B. neutralize the effects of abnormal magnetic phenomena which occur in space.
C. increase the wearer's weight.
D. enable the wearer to operate various instruments by remote controls.
E. enable the wearer to cling to iron surfaces inside or outside of the ship and avoid floating freely in space.

136. The travelers, wearing space suits, sometimes walk about
(1.30) on the outside of the ship while the ship is moving through space. They are subject to all of the following hazards *except*

A. being struck by meteorites.
B. becoming dangerously chilled.
C. being blown off the ship.
D. being exposed to cosmic rays.
E. suffering from lack of oxygen.

137. On approaching a planet, the space navigators turn the
(1.30) ship around so that the tail of the ship is pointed toward the surface because

A. the control room of the ship would otherwise be upside down.
B. the tail is heavier than the nose.
C. the tail is not so sharp as the nose, and would not become stuck in the surface so easily in case of an emergency landing.
D. they wish to be in a position to take off.
E. they wish to slow their fall by firing their rocket motors toward the surface.

138. If the landing is on the moon the travelers in space
(1.30) suits are shown to carry heavy loads with ease, and to take tremendous steps while running because

A. of the excitement of being in a new and strange environment.
B. there is less gravitation attraction on the moon than on earth.
C. the earth is pulling them away from the moon.
D. of the absence of air on the moon.
E. they have more energy on the moon.

139. The travelers on the moon see the sun and other stars
(1.30) shining in a black sky because the

A. atmosphere on the moon is dark.
B. moon is nearer the stars.
C. moon possesses no atmosphere.
D. moon's surface is extremely cold.
E. travelers have dark glass in the windows of their space suits.

140. Archimedes' principle states that
(1.30)

A. the pressure at any point in a liquid is equal in all directions.
B. pressure applied to a confined liquid is transmitted equally throughout the liquid.
C. water will rise in a capillary tube to a height such that the surface tension is balanced by the weight of the water elevated.
D. the pressure at any depth in a liquid is measured by the product of the height and the density of the liquid.
E. a body displacing any amount of fluid is buoyed up by a force equal to the weight of fluid displaced.

141. A simple machine *cannot*
(1.30)

A. change the direction of an applied force.
B. substitute a large force for a small force.
C. have a mechanical advantage of 100.
D. overcome a resistance greater than the applied force.
E. increase the energy put into it.

142. Trucks 1 and 2 are identically constructed. Truck 1 is
(1.31) empty but truck 2 is carrying 20,000 pounds of load which makes its total weight 3 times that of truck 1. Both trucks roll down a hill and coast up the other side. Truck 2 will travel

A. the same distance up the other side as truck 1.
B. one-third as far as truck 1.
C. three times as far as truck 1.
D. nine times as far as truck 1.

143. A rocket ship's ability to travel in space may best be
(1.30) explained by

A. Newton's Law of Gravitation.
B. Newton's Law of Action and Reaction.
C. F = ma.
D. "neither the speed of a body nor its direction of motion will change unless a force from the outside acts to cause the change."
E. Kepler's Law of Equal Areas.

144. Centripetal force and centrifugal force are an applica-
(1.30) tion of the physical law which stated that

A. a combination of two of the following is correct.
B. a moving body continues in a straight line unless acted upon by an external force.

C. to every action there is an equal and opposite reaction.
D. the acceleration which a force can give a body is proportional to the magnitude of the force and inversely proportional to the mass of the body.
E. every particle in the universe attracts every other particle with a force proportional to the product of the masses and inversely proportional to the square of the distance between them.

145. (1.30) It is necessary that a locomotive move a car located on a parallel track. The tracks are 18 feet apart and a 48-foot cable joins the locomotive to the car. What percent more force does the locomotive have to exert than if it were located on the same track as the car? Disregard changes in friction. To solve this problem

A. more data would be required.
B. either or all of the following three methods could be used.
C. a vector diagram could be used.
D. the theorem of Pythagoras could be applied.
E. the trigonometric functions could be used.

146. (3.00) In a situation similar to the preceding item the tracks were 64 feet apart and the cable was 100 feet long. A pull of 9,604 pounds moved the car. Using only the mathematical techniques included in your course in physical science, which of these values could be calculated with only the data given?

A. All of the following three.
B. The force necessary if the locomotive were on the same track as the car.
C. The angle made by the cable and the track on which the locomotive is located.
D. The force tending to pull the car directly toward the track occupied by the locomotive.
E. None of the above three.

147. (1.30) Which of the following ideas did Galileo do most toward disproving by his experiment with falling bodies at the Tower of Pisa?

A. Weight is something possessed by an object just as it possesses color or hardness.
B. The amount of motion within an object is proportional to the mass of the object.
C. Gravity acts chiefly on the surface of bodies.
D. Air resistance does not affect the speed of a falling body.
E. A large object is buoyed up by the same amount as a small object.

148. (1.30) The lifting force produced when air flows over a curved surface bears the greatest relationship to

A. Pascal's principle. **B.** Bernoulli's principle.
C. viscosity. **D.** surface tension.
E. hydrostatic pressure.

149. (1.30) Conservation of angular momentum means that in an isolated system

A. all angular momentum is put to a useful purpose.
B. the total angular momentum is constant.
C. the angles must add up to 360° when the momentum is constant.
D. if the mass is doubled and the velocity halved, the radius of rotation would be halved.
E. the total angular momentum is always zero.

150. (1.30) When a body is in equilibrium under the action of several forces it is always true that

A. the forces are all applied at one point.
B. the forces are all composed of equal and opposite pairs of forces.
C. the sum of the components of all the forces in any direction is zero.
D. any two of the forces are balanced by a third force.
E. the lines of action of the forces all pass through the center of gravity of the body.

151. (1.30) Pascal's principle

A. enables us to determine the buoyant force on a submerged object.
B. explains the action of the hydraulic press.
C. applies to gases only.
D. depends upon changes in the absolute temperature.
E. applies only to a saturated vapor.

152. (1.30) A ship floats because

A. it displaces a weight of water equal to its own weight.
B. the air in the hold is buoyant.
C. the surface tension of the water prevents it from sinking.
D. water is nearly incompressible.
E. its shape corresponds to that of the flow-lines of the water.

153. (1.30) "A metal cylinder submerged in a fluid displaces a volume of the fluid equal to its own volume." This statement is

A. Pascal's paradox. **B.** Archimedes' principle.
C. Pascal's principle. **D.** correct. **E.** incorrect.

154. (1.30) In Simple Harmonic Motion the acceleration is

A. constant.
B. proportional to the displacement from the central position.
C. inversely proportional to the displacement from the central position.
D. greatest when the velocity is greatest.
E. so irregular that it cannot be expressed in mathematical form.

155. (1.30) The resultant between two forces, at a point, acting at right angles to each other

A. is always less than one of the forces.
B. is the average of the forces.
C. always bisects the angle between the lines of action of the forces.
D. must be greater than either of the forces.
E. may be equal to one of the forces.

156. (1.30) For which of these is the buoyant force of fluids of usually *little* or *no* value?

A. Lifting objects with hydraulic jacks.
B. Making stratosphere flights with balloons.
C. Automatic devices for closing valves, when the water in a tank has reached level.
D. Lifting a submerged ship.

157. (1.30) A car is traveling due westward along a level road at a constant speed of 20 miles per hour. With respect to the earth's surface, choose the correct statement or statements among those below.

1. The driving force of the engine in a westward direction is greater than the eastward frictional forces acting on the car.
2. There is no resultant unbalanced horizontal force acting on the car.
3. There is no resultant unbalanced vertical force acting on the car.

The correct selection of statements includes only

A. 1. **B.** 2. **C.** 3. **D.** 1 and 3. **E.** 2 and 3.

158. (1.30) In a collision between two perfectly elastic bodies

A. the total momentum and the total kinetic energy of the bodies both remain constant, before, during, and after the collision.
B. the total momentum of the two bodies remains constant while the total kinetic energy first diminishes (being compensated for by potential energy of the bodies), then increases again to its original value.
C. the total kinetic energy of the two bodies remains constant, while the total momentum first diminishes in magnitude (remaining unchanged in direction) on account of the compressive forces exerted between the bodies, then increases again to its original value.
D. both the total momentum and the total kinetic energy of the bodies diminish, as the bodies are deformed by the collision; then as the bodies rebound, the total momentum and the total kinetic energy increase to their original values.
E. both the total momentum and the total kinetic energy of the bodies first diminish, owing to the action of forces between the bodies as they are deformed by the collision and the consequent increase of potential energy; then as the bodies rebound, the total momentum increases to its original value, while the kinetic energy increases to a value less than its original one.

159. (2.30) If the ball continued to roll down the incline, at the end of 10 time-intervals it would have traveled most nearly

A. 700 cm. **B.** 1400 cm. **C.** 2100 cm.
D. 2800 cm. **E.** 3500 cm.

160. (4.20) The acceleration of the ball during the third time-interval was

A. equal to that during the second time-interval.
B. three times that during the second time-interval.
C. nine times that during the second time-interval.
D. thirty-two times that during the second time-interval.
E. not comparable to that during the second time-interval from the data given.

161. (1.22) In order to determine the momentum of the ball at the end of four time-intervals, it would be necessary to know also

A. all of the following.
B. the angle of elevation of the board.
C. the coefficient of friction. **D.** the mass of the ball.
E. the actual time equivalent to four time-intervals.

162. (2.00) In order to predict what fraction of the volume of a cylinder projects from a fluid in which it is placed, one must know

A. only the weight of the cylinder.
B. only the volume of the cylinder.
C. only the volume of fluid displaced.
D. only the densities of the cylinder and the fluid.
E. the density of the cylinder, its dimensions, and the volume of fluid.

163. (2.00) In order for the method of *reductio ad absurdum* (proof by contradiction), as used by Archimedes, to give a valid proof of a theorem, the theorem must state

A. a proposition verifiable from external sources.
B. a proposition whose sole contrary can be stated by insertion of the word "not" in the proposition.
C. a numerical relation between two quantities.
D. a fact of nature which can be expressed quantitatively.
E. any proposition which is not contradicted by the postulate underlying it.

164. (2.00) The evidence for the validity of Newton's general theory of the motion of bodies, developed in Books I and II, is to be found in

A. the fact that the propositions of these books are demonstrated mathematically on the basis of the Laws, and that the Laws follow from the Definitions.
B. certain common facts of experience, such as the persistence of motion and the vector character of force, which lead directly to Newton's Laws, from which the rest of his theory follows.
C. the success with which Newton's Laws of Motion, with the concepts of mass, force, and momentum, can be applied in dealing with motions of various kinds of real bodies.
D. the fact that Newton's theory is a natural generalization of Galileo's and that it leads to a more general theory of gravity than Galileo achieved.
E. certain crucial experiments performed by Newton, to demonstrate the correctness of his Laws of Motion.

165. (2.00) In Galileo's theory of falling bodies, the *cause* of the behavior of the falling bodies is considered to be

A. the inherent simplicity of nature.
B. a power of "force" which is put into a body by the hand or other object that releases it.
C. an action exerted upon the body by a force which is present at all places about the earth, and which acts in the direction of the earth's center.
D. the natural tendency of bodies to move horizontally with uniform motion, vertically with uniform acceleration.
E. undetermined by Galileo's investigation and irrelevant, since the theory is merely concerned with giving a correct mathematical description of the behavior of falling bodies.

166. (2.00) The evidence for the correctness of Galileo's theory of falling bodies is to be found in

A. the simplicity of the theory, which is clearly in accord with the postulated simplicity of nature.
B. the relation between the behavior of freely falling bodies, and that of bodies which are forcibly projected upwards.
C. the definition of uniform motion and of naturally accelerated motion.

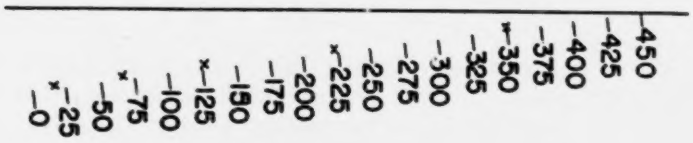
D. the correspondence between observable or measurable aspects of the behavior of falling bodies, and the mathematically demonstrable properties of uniformly accelerated motion.

E. the definition of force, together with the observed characteristics of the behavior of falling bodies and projectiles.

167. (2.00) Which of the following is a pair of quantities which Salviati *assumes* to correspond with one another, *in order to draw his conclusion* from the outcome of the experiment?

A. Weight of body—Speed with which the body strikes.
B. Height of fall—Duration of fall.
C. Weight of body—Force of blow against stake.
D. Speed with which the body strikes—Depth to which stake is driven.
E. Duration of fall—Force of blow against stake.

Items 168 - 172 refer to the diagram showing a paper tape with numbers indicating centimeters which was fastened to an inclined board. The crosses indicate the instantaneous position occupied by a ball at successive time-intervals as the ball rolls down the incline ($d = \frac{1}{2}at^2$).



168. (2.10) During the fifth time-interval the ball traveled most nearly

A. 25 cm. **B.** 225 cm. **C.** 100 cm.
D. 125 cm. **E.** 350 cm.

169. (2.20) If the time elapsed were plotted on the horizontal axis and the distance traveled on the vertical axis, a graph of the data from the tape would take the general form of the diagram.

170. (2.30) If the ball continued to roll down the incline at the end of 10 time-intervals it would have traveled most nearly

A. 700 cm. **B.** 1400 cm. **C.** 2100 cm.
D. 2800 cm. **E.** 3500 cm.

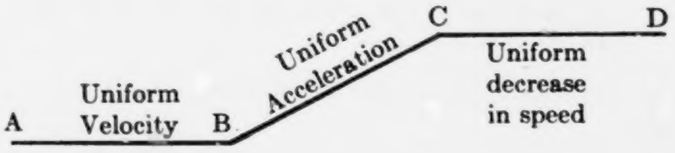
171. (4.20) The acceleration of the ball during the third time-interval was

A. equal to that during the second time-interval.
B. three times that during the second time-interval.
C. nine times that during the second time-interval.
D. thirty-two times that during the second time-interval.
E. $\sqrt{3}$ times that during the second time-interval.

172. (1.22) In order to determine the momentum of the ball at the end of four time-intervals, it would be necessary to know also

A. all of the following.
B. the angle of elevation of the board.
C. the coefficient of friction.
D. the mass of the ball.

Items 173 - 181 refer to the following data and diagram. A locomotive starts from rest on a horizontal track A-B and, with uniform acceleration, travels a distance of 1200 feet in the first minute. It then begins to ascend a uniform incline B-C, up which it is found to run with uniform velocity. Some time later it comes to another horizontal track C-D and, by application of the brakes, its speed is decreased uniformly until it comes to rest. Track A-B is to be considered the base level of potential energy.



For each item 173 - 178 select from the key the most appropriate response.

KEY

A. The quantity is constant but not zero.
B. The quantity is increasing.
C. The quantity is decreasing.
D. The quantity is zero.
E. No prediction can be made without additional data.

173. (1.31) The total energy at any point along track B-C.

174. (1.12) The potential energy along track C-D.

175. (2.10) The change in momentum along track B-C.

176. (2.10) The acceleration along track C-D.

177. (2.10) The acceleration along track B-C.

178. (2.10) The momentum along track A-B.

179. (2.10) The acceleration on track A-B is

A. 1200 ft./min. **B.** 1200 ft./sec.
C. 20 ft./sec.^{2} **D.** ⅔ ft./sec.^{2} **E.** none of these.

180. (2.10) The velocity at the end of the first minute on track A-B is

A. 1200 ft./min. **B.** 2400 ft./sec.^{2}
C. 40 ft./sec. **D.** 20 ft./sec. **E.** none of these.

181. (2.10) In one minute on track B-C, the locomotive will travel a distance of

A. 2400 ft. **B.** 1200 ft. **C.** 600 ft.
D. 40 ft. **E.** none of these.

Items 182 - 188. A body falls freely under the action of gravity. The body starts from rest. Assume ideal conditions, no air resistance. After each exercise number on the answer sheet, blacken the *one* letter space which designates the correct answer.

182. (1.10) The initial velocity of the body is

A. 32 ft./sec. **B.** 16 ft./sec. **C.** zero.
D. not specified.

183. (1.10) The acceleration of this body is

A. 16 ft./sec. **B.** variable. **C.** 16 ft./sec.^{2}
D. 32 ft./sec.^{2} **E.** 32 ft./sec.

184. (2.10) The velocity of this body after one second is

A. 16 ft./sec. **B.** 32 ft./sec.^{2} **C.** 32 ft./sec.
D. 16 ft./sec.^{2}

185. (2.10) The distance this body falls the first second is

A. 32 ft. **B.** 16 ft. **C.** 8 ft. **D.** 64 ft.
E. 128 ft.

186. (2.30) At a certain instant the velocity of this body is 100 ft./sec., one second later the speed of the body is

A. 68 ft./sec. **B.** 84 ft./sec. **C.** 100 ft./sec.
D. 116 ft./sec. **E.** 132 ft./sec.

187. (2.30) If the body has fallen, after a certain time, "t," a distance of 10 ft., how far will the body have fallen in a total time of "2t"?

A. 20 ft. **B.** 30 ft. **C.** 42 ft. **D.** 40 ft.
E. 26 ft.

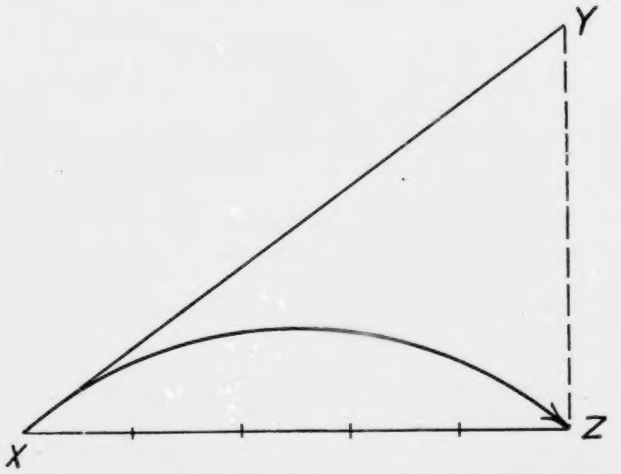
188. (1.31) If, at a certain instant, the kinetic energy of this body has increased by 100 foot poundals, its potential energy

A. has also increased 100 foot poundals.
B. has remained unchanged.
C. has decreased 50 foot poundals.
D. has decreased 100 foot poundals.
E. can't be specified from data given.

189. (2.10) A cubic centimeter of lead weighs 11.4 grams in air. When immersed in water, the apparent weight, in grams, of the lead will be

A. 10.4 **B.** 11.4 **C.** 12.4 **D.** 11.3 **E.** 11.5

190. (2.10) Assuming that air resistance is negligible, a bullet fired from a gun at X strikes the ground at Z seven seconds later. If it were not for the earth's gravitational attraction, the projectile would reach point Y in seven seconds. What is the distance from Y to Z?



A. 112 feet. **B.** 224 feet. **C.** 784 feet.
D. 1568 feet.
E. Insufficient data is given to determine this distance.

191. (1.22) What is the distance from X to Z?

A. 224 feet. **B.** 784 feet. **C.** 1082 feet.
D. 1568 feet.
E. Insufficient data is given to determine this distance.

192. (1.30) The fact that the bullet reached Z in the time it would take to fall from rest at Y *best* illustrates

A. the law of falling bodies, $s = \frac{1}{2}gt^2$.
B. the law of gravitation.
C. the effect of terminal velocity.
D. the law of independence of motion.
E. none of the above laws.

193. (2.10) If the bullet fell from rest at Y to Z, what velocity would it have on striking Z?

A. 49 feet per second. **B.** 112 feet per second.
C. 224 feet per second. **D.** 256 feet per second.
E. 400 feet per second.

Items 194 - 196 refer to the following data. The piston face in a certain steam engine has an area of 40 square inches, and the pressure of the cylinder steam against the piston face is 150 pounds per square inch.

194. (2.10) What is the force (in pounds) exerted by the cylinder steam on the entire piston face, tending to push the piston outward?

A. 6000. **B.** 40. **C.** 150. **D.** 4. **E.** 96,000.

195. (2.10) If the atmosphere outside the cylinder exerts a force of 600 pounds tending to push the piston *inward*, what is the resultant force (in pounds) on the piston which is effective in moving the piston outward?

A. 5400. **B.** 6000. **C.** 6600. **D.** 600.
E. 150.

196. (2.10) If the steam pressure in the cylinder remains unchanged (and of course the atmosphere pressure outside the cylinder does so), and the piston moves *outward* through a distance of 2 feet, how much work (in foot-pounds) is done on the piston by the above resultant force?

A. 1200. **B.** 12,000. **C.** 300. **D.** 10,800.
E. 13,200.

Items 197 - 205 refer to the following data:

Given: "g" = 32 ft./sec.^{2}

A man weighing 200 lb. climbs a 20 ft. vertical ladder in 10 sec.
A boy weighing 100 lb. climbs a 20 ft. vertical ladder in 5 sec.

For each item select from the key the most appropriate response.

KEY

A. The answer in case of the man is greater.
B. The answer in case of the boy is greater.
C. The answer in either case is the same, but not zero.
D. The answer becomes zero in either case.

197. (2.10) The momentum of the man and the boy when they are at the top of the ladder.

198. (2.10) If the man and the boy fell off the ladder, the potential energy when they were half-way to the ground.

199. (2.10) The work done by the man and the boy in climbing the ladder.

200. (2.10) If they fell off the ladder, the velocity just before impact with the ground.

201. (2.10) If they fell off the ladder, the momentum just before impact with the ground.

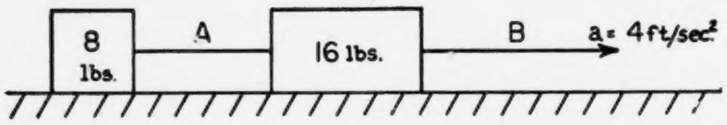
202. (2.10) The sum of the kinetic and potential energy when they had climbed half-way up the ladder.

203. (2.10) The average velocity of the man and the boy in climbing the ladder.

204. (2.10) The force of gravity on the man and the boy at the top of the ladder.

205. (2.10) The power developed by the man and the boy in climbing the ladder.

Items 206 and 207 refer to the following data and diagram. A 16 lb. mass and an 8 lb. mass on a horizontal frictionless surface are connected by cord A and are pulled along the surface with a uniform acceleration of 4 ft./sec.^{2} by a second cord B.



206. (2.10) What is the force exerted by cord A on the 8 lb. mass?

A. 96 pounds. **B.** 96 poundals. **C.** 32 pounds.
D. 32 poundals. **E.** None of these.

207. (2.10) What is the force exerted by cord B?

A. 96 pounds. **B.** 96 poundals. **C.** 64 pounds.
D. 64 poundals. **E.** None of these.

208. (2.10) A hydraulic press has one piston 2 in. and the other 8 in. in radius. If a force of 100 lb. is applied to the smaller piston, the force exerted on the large piston will be

A. 6¼ lb. **B.** 25 lb. **C.** 100 lb. **D.** 400 lb.
E. 1600 lb.

209. (2.10) A test pilot zooms straight down at a speed of about 320 feet per second, then flattens out to horizontal flight within a period of two seconds. Besides the normal force of gravity on the pilot the average upward push of the plane against the pilot is approximately

A. 2 times the force of gravity at the earth's surface.
B. 3 times the force of gravity at the earth's surface.
C. 5 times the force of gravity at the earth's surface.
D. 10 times the force of gravity at the earth's surface.
E. 20 times the force of gravity at the earth's surface.

Items 210 and 211 refer to the following data. An airplane is flying horizontally with an eastward velocity of 300 feet per second when the pilot drops a bomb directly over a place X on the earth's surface. The bomb requires 10 seconds to fall to the ground.

210. (2.10) Neglecting air resistance, how high was the airplane when the bomb was dropped?

A. 3200 feet. **B.** 800 feet. **C.** 400 feet.
D. 1600 feet. **E.** 2400 feet.

211. (2.10) Neglecting air resistance, where does the bomb strike the earth's surface?

A. 3000 feet east of X. **B.** 1600 feet west of X.
C. 3200 feet west of X. **D.** 800 feet east of X.
E. 2400 feet east of X.

212. (2.10) A car travelling with a northward velocity of 80 feet per second is brought to rest in 6 seconds by a uniform retardation. How far northward does the car travel while being brought to rest?

A. 480 feet. **B.** 120 feet. **C.** 60 feet.
D. 240 feet. **E.** 360 feet.

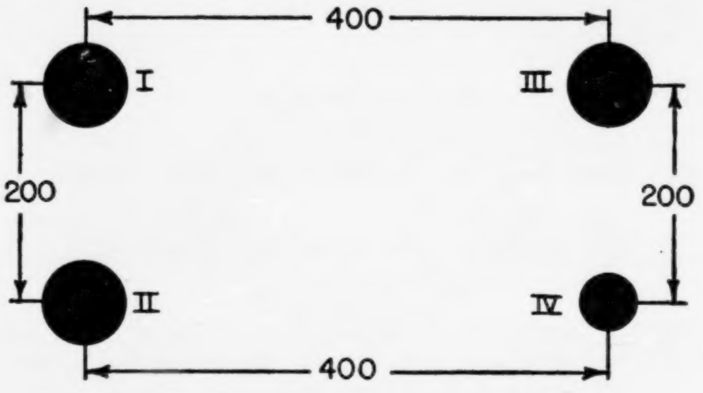
213. (2.10) A certain force is capable of giving a 1000 lb. mass an acceleration of 10 ft./sec.^{2}. This same force would accelerate a 500 lb. mass

A. 5 ft./sec.^{2} **B.** 10 ft./sec.^{2} **C.** 20 ft./sec.^{2}
D. 2 ft./sec.^{2} **E.** none of these.

Item 214 deleted.

Items 215 - 218.

In the diagram I, II, and III each have a mass of 1000 grams, while IV has a mass of 500 grams. The distances between the masses are given in centimeters. Recalling that the Law of Universal Gravitation may be expressed as $F = G\frac{Mm}{d^2}$ masses at a time, and considering the attraction between only two of the masses at a time and disregarding the presence of the other two, answer the questions given below the diagram.



215. (2.10) Between which two of the masses is the force of attraction greatest?

A. I and II. **B.** I and III. **C.** I and IV.
D. II and III. **E.** III and IV.

216. (2.10) Between which two of the masses is the force of attraction the least?

A. I and II. **B.** I and III. **C.** I and IV.
D. II and III. **E.** III and IV.

217. (2.10) The attraction between I and II is________as great as the attraction between III and IV.

A. one-fourth. **B.** one-half. **C.** twice.
D. four times. **E.** none of the above.

218. (2.10) The attraction between I and II is________as great as the attraction between III and IV.

A. one-fourth. **B.** one-half. **C.** twice.
D. four times.

Items 219 - 228. In the table below the distances traveled *each* second by objects A, B. C, D, and E are given in feet. Assume that there is no friction.

	A	B	C	D	E
First Second	1	6	16	36	20
Second Second	3	6	48	24	16
Third Second	6	6	80	18	12
Fourth Second	10	6	112	24	8
Fifth Second	15	6	144	36	4

After each item number on the answer sheet, blacken the one lettered space which designates the moving object to which the item refers.

219. (2.10) This could be an object falling from rest near the earth's surface.

220. (2.10) This object comes to rest at the end of the fifth second.

221. (2.10) This object has a variable, but always positive acceleration.

222. (2.10) This object has a uniform velocity.

No acceptable answer - see letter.

223. (2.10) The acceleration of this object is constant, but changes in sign from negative to positive.

224. (2.10) The acceleration of this object is 32 feet per second per second.

225. (2.10) This object has no acceleration.

226. (2.10) No force is acting on this object.

227. (2.10) This object has a uniformly decreasing velocity.

228. (2.10) The increasing velocity of this object is due to a uniform force.

229. (2.10) An automobile was traveling 10 mi./hr. at one o'clock and at three o'clock the same afternoon it was traveling 30 mi./hr. If its velocity increased at a constant rate, the acceleration of the automobile would be

A. 5 mi./hr./hr. **B.** 10 mi./hr./hr.
C. 15 mi./hr./hr. **D.** 20 mi./hr./hr.
E. 30 mi./hr./hr.

Items 230 - 233 may require the use of one or more of the following equations.

$V_f = V_i + at$
$V_f = at$
$d = \frac{1}{2}at^2$
$d = V_1t + \frac{1}{2}at^2$
$d = V_at$
$F = ma$
$F = \frac{KMm}{d^2}$

$V_a = V_f + V_i$
V_f final velocity
V_i initial velocity
V_a average velocity
a acceleration
d distance
t time
980 dynes = 1 gram of force.

230. (2.10) An object moving with a velocity of 20 feet per sec. is increased to a velocity of 80 ft. per sec. in 20 sec. The uniform acceleration is

A. ¼ ft. per sec.^{2} **B.** 3 ft. per sec.^{2}
C. 4 ft. per sec.^{2} **D.** 5 ft. per sec.^{2}
E. 60 ft. per sec.^{2}

231. (2.10) If a car has a uniform acceleration of 5 ft. per sec.^{2}, and it starts from rest, its velocity after 10 sec. will be

A. 2 ft. per sec. **B.** 100 ft. per sec.
C. 250 ft. per sec. **D.** 500 ft. per sec.
E. none of these.

232. (2.10) A car having a velocity of 10 ft. per sec. is uniformly accelerated to a velocity of 40 ft. per sec., in 10 sec. In this time it will travel

A. 100 ft. **B.** 150 ft. **C.** 200 ft. **D.** 250 ft.
E. none of these.

233. (2.10) If a force of 49000 dynes produces an acceleration of 100 cm. per sec.^{2} on a certain mass, the mass is

A. ½ gm. **B.** 490 gm. **C.** 480.2 kg.
D. .5 dynes. **E.** 50 gm.

For items 234 - 237 use any of the following which you may need in the solution of the problems:

P. E. = Mgh
K. E. = ½ Mv^2
F = Ma
W = Fd

$d = \frac{1}{2}at^2$
$v = at$
$d = v_{av.}t$
g = 980 cm./sec.^{2} or 32 ft./sec.^{2}

234. (2.10) If a 100 gm. wt. fell from a plane which was in horizontal flight, and the weight had acquired a kinetic energy of 98,000,000 ergs, how far has the weight fallen from the plane?

A. 100 cm. **B.** 980 cm. **C.** 980000 cm.
D. 100000 cm. **E.** None of the above.

235. (2.10) If a 10 lb. stone fell freely for 2 sec. and acquired a velocity of 64 ft. per sec. it fell

A. 32 ft. **B.** 64 ft. **C.** 16 ft. **D.** 128 ft.
E. none of these.

236. (2.10) If the stone in problem 235 fell for three seconds, in the time-interval from two seconds to three seconds, the average velocity would be

A. 32 ft. per sec. **B.** 64 ft. per sec.
C. 16 ft. per sec. **D.** 80 ft. per sec.
E. none of these.

237. (2.10) During the time-interval in the preceding problem, the stone fell

A. 80 ft. **B.** 32 ft. **C.** 96 ft. **D.** 64 ft.
E. 48 ft.

238. (2.10) If a 4 lb. stone fell freely from rest for 2 sec., it acquires a velocity of

A. 32 ft. per sec. **B.** 64 ft. per sec.
C. 128 ft. per sec. **D.** 256 ft. per sec.
E. none of these.

239. (2.10) A bucket weighing 10 lb. contains 20 lbs. of water which does not approach filling the bucket. If a 4 lb. block of wood is floated on top of the water the total weight should be (specific gravity of wood is .8).

A. 30.0 lb. **B.** 35.0 lb. **C.** 33.2 lb.
D. 34.2 lb. **E.** none of these.

240. (2.10) An automobile is travelling at a velocity of 30 miles per hour (44'/second) north. It accelerates in this direction at the rate of 20 feet per sec. for 2 secs. Its final velocity will be approximately

A. 40 feet/sec. **B.** 70 feet/sec. **C.** 84 feet/sec.
D. 123.2 miles/hr. **E.** none of the above.

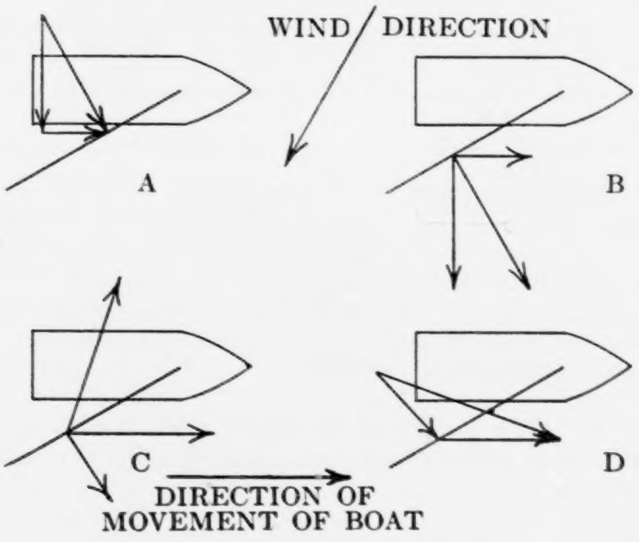
241. (2.10) A man holds 100 pounds of sugar 5 feet above the floor for 10 seconds. He expends in horsepower

A. $\frac{100 \times 5}{10 \times 550}$ **B.** $\frac{100 \times 5}{550}$
C. $\frac{550 \times 10}{500}$ **D.** $\frac{100}{5 \times 550 \times 10}$
E. none of these.

242. (2.10) Two horses are drawing a tree stump from the ground. One is pulling to the north with a force of 300 lbs. and the other to the east with a force of 400 pounds. The magnitude of the resultant is

A. 225. **B.** 350. **C.** 400. **D.** 375.
E. none of these.

243. (2.10) A sailboat can sail into the wind. In so doing the only effective force of the wind acting on the sail is perpendicular to the sail. Which of the diagrams correctly resolves this effective force into the force necessary to move the boat forward and one other force?



A. A. **B.** B. **C.** C. **D.** D.
E. Two of the above.

244. (1.10) The arrows in the diagram are vectors because

A. they represent forces.
B. they are not of infinite length.
C. they make it possible to depict forces on a plane surface.
D. they represent both magnitude of force and direction.
E. their length is proportional to the magnitude of the quantity (force) represented.

245. (2.10) If a body weighed 100 lb. at the earth's surface (radius 4000 mi.) and it could be taken to a spot 8000 mi. from the center of the earth, it would weigh (Law of Gravitation $F = \frac{kMm}{d^2}$)

A. 400 lb. **B.** 200 lb. **C.** 100 lb. **D.** 50 lb.
E. 25 lb.

246. (2.10) If the earth were twice its present diameter and double its present mass, a boy now weighing 100 lb. would weigh

A. 100 lb. **B.** 25 lb. **C.** 400 lb. **D.** 50 lb.
E. 800 lb.

Suggestion: $F = \frac{kMm}{d^2}$

Items 247 - 249 require the use of one or more of the following equations of motion. Use whichever are necessary.

$V_f = V_i + at$
$V_f = at$
$d = \frac{1}{2} at^2$
$d = V_i t + \frac{1}{2} at^2$
$d = V_a t$

V_f	final velocity
V_i	initial velocity
V_a	average velocity
a	acceleration
d	distance
t	time

247. (2.10) A car moving with a velocity of 20 ft. per sec. is increased to 60 ft. per sec. in 20 sec. The uniform acceleration is

A. 2 ft. per sec.^{2} **B.** 3 ft. per sec.^{2}
C. 4 ft. per sec.^{2} **D.** 40 ft. per sec.^{2}
E. —40 ft. per sec.^{2}

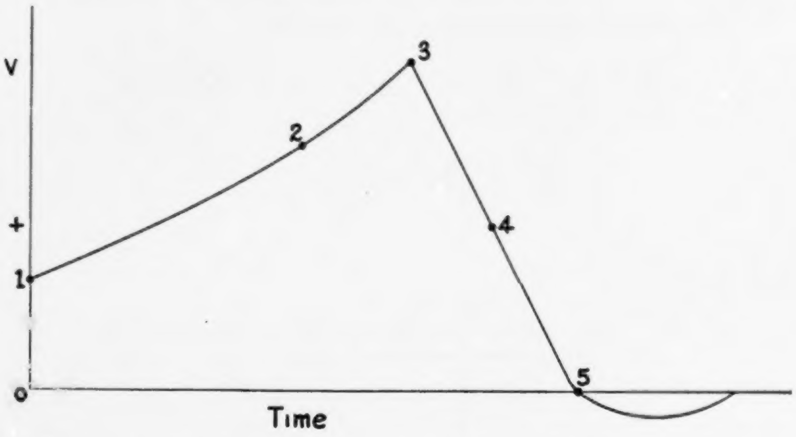
248. (2.10) If a car has a uniform acceleration of 3 ft. per sec.^{2} and starts from rest, its velocity after 10 sec. will be

A. 3⅓ ft. per sec. **B.** 30 ft. per sec.
C. 150 ft. per sec. **D.** 300 ft. per sec.
E. none of these answers.

249. (2.10) If a car has a velocity of 20 ft. per sec. and is uniformly accelerated to a velocity of 50 ft. per sec., in 10 sec., it will have traveled

A. 150 ft. **B.** 200 ft. **C.** 300 ft. **D.** 350 ft.
E. none of these answers.

Items 250 - 252 refer to the following graph showing the change, with time, of velocity, V, of an automobile. The automobile is moving along a straight road.



250. (2.10) At which point is the car stationary?

251. (2.10) At which point is the velocity at a maximum?

252. (2.10) At which of the points indicated is the acceleration at a maximum?

253. (2.10) A two-gram mass which has fallen freely for 5 seconds has a momentum in gram/centimeter/sec. of

A. 19,600. **B.** 1960. **C.** 4900. **D.** 9800.
E. 24,500.

For items 254 - 262 select from the key the numerical response required to answer the item.

KEY

A. Two. **B.** Four. **C.** Six. **D.** Nine.
E. Some other numerical value.

Items 254 - 257 refer to the following conditions: A ball, starting from rest, rolls down a long inclined plane with a uniform acceleration of 4 cm./sec.^{2}

254. (2.10) The numerical value of the velocity of the ball 1 sec. after starting down the incline.

255. (2.10) The numerical value of the distance traveled by the ball in the first second.

256. (2.10) The numerical value of the acceleration ½ sec. after the start.

257. The numerical value of the average velocity during the
(2.10) second second.

258. If the initial illumination on a surface was 4 ft. candles,
(2.10) the numerical value of the illumination after the distance from the source is doubled.

259. The numerical value of the specific gravity of a sub-
(2.10) stance when its density is 6 gm./cm.^{3}.

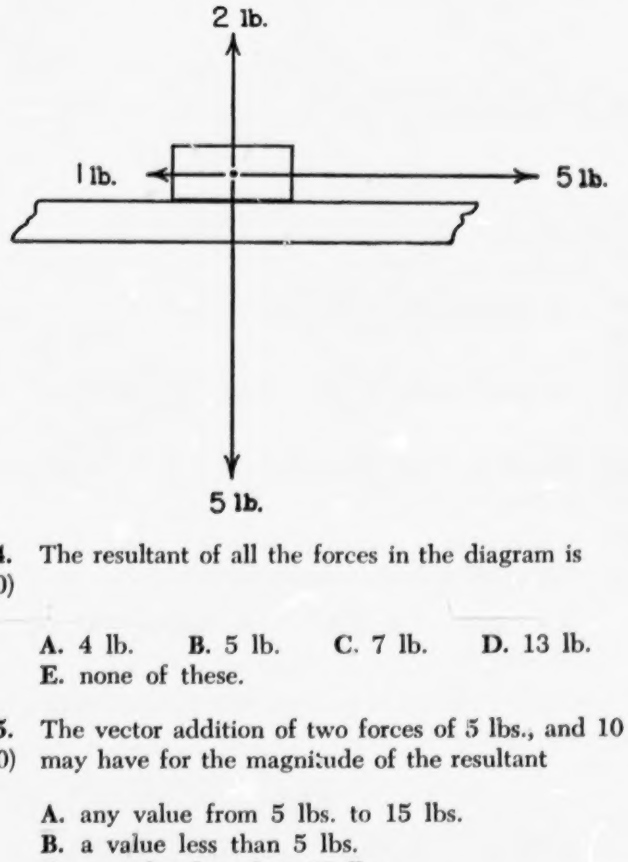
260. The numerical value of the sum of *all* the coefficients
(2.10) after the expression $H_2S + O_2 \rightarrow H_2O + SO_2$ is balanced.

261. The number of atoms of oxygen required in the balanced
(2.10) equation of the preceding item.

262. If the force of attraction between unlike magnet poles
(2.10) were 3 dynes when the distance apart was 3 cm., the number of times the force would be increased by placing them 1 cm. apart.

263. A block resting on a table is acted upon by the forces
(2.10) shown in the diagram where the downward force is due to the weight of the body. The force available to accelerate the body to the right is

A. 4 lb. **B.** 5 lb. **C.** 7 lb. **D.** 13 lb.
E. none of these.



264. The resultant of all the forces in the diagram is
(2.10)

A. 4 lb. **B.** 5 lb. **C.** 7 lb. **D.** 13 lb.
E. none of these.

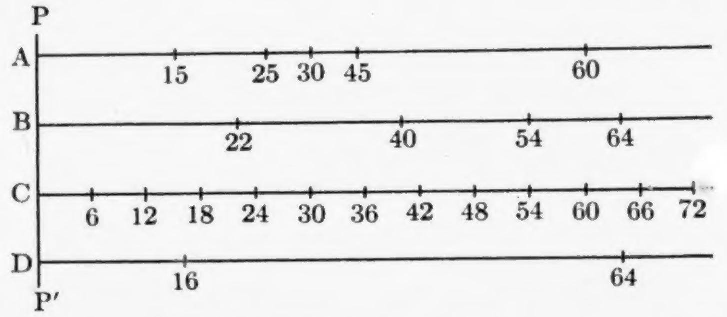
265. The vector addition of two forces of 5 lbs., and 10 lbs.
(2.10) may have for the magnitude of the resultant

A. any value from 5 lbs. to 15 lbs.
B. a value less than 5 lbs.
C. no value less than 10 lbs.
D. values up to 50 lbs. **E.** a zero value.

266. Given a body starting from rest and moving with uni-
(2.10) formly accelerating motion:

A. the acceleration produced is directly proportional to the force acting on the body providing the mass of the body is not changed.
B. the acceleration produced by a constant force is directly proportional to the mass of the body.
C. the acceleration can never be greater than that of a freely falling body.
D. the force causing the uniform acceleration must continually increase, since the velocity is continually increasing.
E. the acceleration produced will be equal to the change of distance per unit time.

Items 267 - 278.



The horizontal lines shown above represent the paths of four moving objects A, B, C, and D. All crossed line PP' at the same instant, except D which started from PP' at that instant. The crossbars indicate the positions of the objects at the ends of successive seconds. The small numbers at the bottom of each crossbar represent the total distance of each crossbar from PP'. Assume that friction is negligible.

After each item number on the answer sheet, blacken the *one* lettered space which designates the moving object to which the item refers.

267. This body travels with constant velocity.
(2.10)

268. This body has a constant positive acceleration.
(2.10)

269. This body has a variable acceleration.
(2.10)

270. This body has no acceleration.
(2.10)

271. A constant force is operating on this body in the direc-
(2.10) tion opposite to its motion.

272. No force is acting on this body.
(2.10)

273. A changing force is acting on this body.
(2.10)

274. Except for direction, this might be a freely falling body.
(2.10)

275. One can predict that this body will soon come to rest.
(2.30)

276. The distance this body has traveled up to the end of
(2.10) each second can be obtained by multiplying its velocity by the time elapsed.

277. The distance this body has traveled *from PP'* at the
(2.30) end of any given number of seconds is given by $d = \frac{1}{2}at^2$, one half the acceleration times the square of the time.

278. The velocity of this body would be 128 feet per second
(2.30) at the end of the fourth second.

Items 279 - 288.

Each column represents *velocities* in feet per second of bodies *A, B, C, D,* and *E* at times (in seconds) in column *t.* After each item number on the answer sheet, blacken the *one* lettered space on the answer sheet which designates the correct answer. Assume no friction or air resistance.

t	A	B	C	D	E
0 seconds	2	12	4	0	4
1 second	4	9	4	32	7
2 seconds	6	6	4	64	9
3 seconds	8	3	4	96	6

279. (2.10) Uniform motion.

280. (2.10) The net force acting is zero.

281. (2.10) A constant positive acceleration, not starting from rest.

282. (2.10) A freely falling body.

283. (2.10) A constant negative acceleration.

284. (2.10) Variable acceleration.

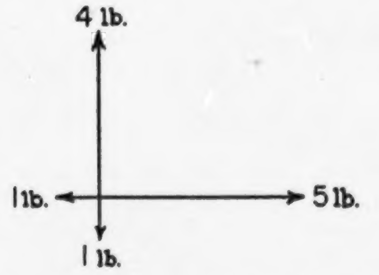
285. (2.10) Acceleration is zero.

286. (2.10) Travels 12 feet in three seconds.

287. (2.10) Travels 16 feet in the first second.

288. (2.30) At the end of the tenth second it would have a velocity of 320 ft./sec.

289. (2.10) In the diagram, the magnitude of the resultant of the vectors is



A. 5 lb. **B.** 2 lb. **C.** 11 lb. **D.** 7 lb.

290. (2.10) When a number of forces act on a point, the point will be in equilibrium *only if*

- **A.** it moves in a straight line at uniform speed.
- **B.** an equilibrant of correct magnitude holds it that way.
- **C.** all the forces acting on the point are of equal magnitude.
- **D.** the resultant of the forces equals zero.
- **E.** every force has another force in the opposite direction to balance it.

291. (2.10) An acceleration of 32 feet/second^2 for a freely falling body means that

- **A.** it falls 32 feet during each second.
- **B.** its velocity in every second averages 32 feet/second.
- **C.** 32 poundals of force are acting on the body.
- **D.** its velocity increases 32 feet/second in every second.
- **E.** its acceleration increases by 32 feet/second^2 in every second.

292. (12.2) A man who weighs 150 pounds jumps from an airplane travelling in horizontal flight at 180 miles per hour (264 feet per second). The plane is flying north and is being drifted by a wind of 20 miles an hour from the east. In three seconds he will have fallen a certain number of feet. All of this information is not necessary to determine the number of feet he will have fallen in this time. The only information necessary is

- **A.** the weight of the man.
- **B.** the speed at which the plane is flying.
- **C.** the fact that the plane is in level flight.
- **D.** the velocity of the wind drifting the plane.
- **E.** none of these is necessary.

293. (2.10) At the end of the three seconds he will have fallen approximately

A. 45 feet. **B.** 135 feet. **C.** 144 feet.
D. 288 feet. **E.** 0 feet.

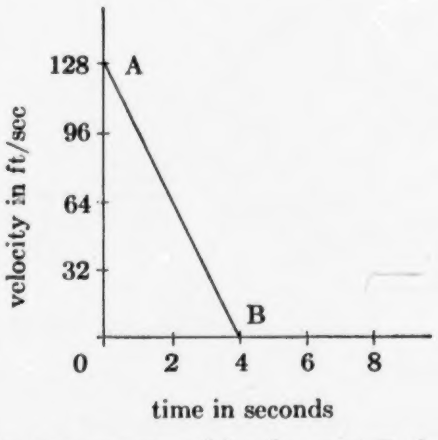
294. (2.10) The resultant of two forces

- **A.** can never be zero.
- **B.** is always greater than either of the forces.
- **C.** is the single force which is equivalent to the two forces.
- **D.** depends upon the magnitude of the two forces only.
- **E.** is always equal to zero.

Items 295 - 297. From the data taken during the flight of a ball thrown vertically into the air, the curve has been plotted.

295. (2.10) The velocity with which the ball started upward is

- **A.** zero. **B.** measured by OA.
- **C.** measured by OB.
- **D.** not indicated on the diagram.
- **E.** measured by AB.



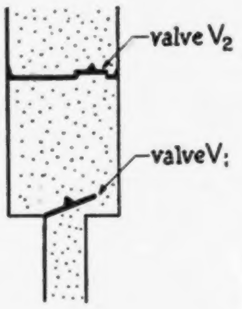
296. (2.10) At the time represented by the point B, the velocity of the ball is

- **A.** the same as at the start.
- **B.** greater than at the start.
- **C.** one half that at the start. **D.** zero.
- **E.** in magnitude the same as at the start, but in direction just opposite.

297. (2.10) At the time represented by the point B, the ball is

- **A.** at its highest point.
- **B.** at the point from which it started.
- **C.** halfway between the starting point and highest point, moving up.
- **D.** halfway between the starting point and highest point, moving down.
- **E.** below the point from which it started.

This diagram, representing the cross section of a certain pump in action, shows the cylinder and connecting pipe full of water.



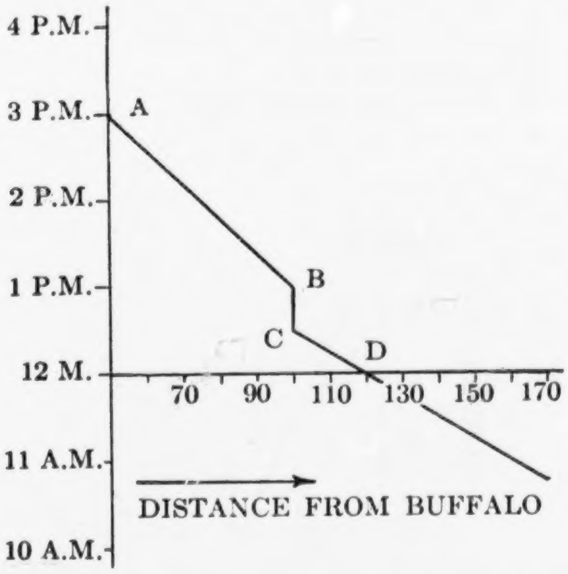
The valve V_2 in the movable piston is closed, while the valve V_1 at the bottom of the cylinder is open.

298. It is clear that
(2.10)

- **A.** the water is being forced downward by the piston.
- **B.** this represents the piston at rest at the bottom of its stroke.
- **C.** this represents the piston at rest at the top of its stroke.
- **D.** the water is now moving upward.
- **E.** the piston is moving downward.

Items 299 - 300.

Assume that the diagram gives a record made every minute by observations of the position of a railroad train, on a straight track, between Albany and Buffalo.



299. From the curve it is evident that
(2.10)

- **A.** the train will reach Buffalo at 5 P.M.
- **B.** the train is not moving toward Buffalo.
- **C.** there is no information about the arrival either in Albany or Buffalo.
- **D.** it is 160 miles from Albany to Buffalo.
- **E.** the train was moving faster at 2 P.M. than at noon.

300. The curve also shows that
(2.10)

- **A.** the train changed direction at noon.
- **B.** at the point D the train was at rest.
- **C.** the line from B to C means that the train had infinite speed.
- **D.** the train picked up speed very rapidly from 1 P.M. to 3 P.M.
- **E.** the train stopped for half an hour 100 miles from Buffalo.

301. At the bottom of a tank filled to a depth of 20 ft. with
(2.10) fresh water, the water pressure is about

A. 20 lbs./sq. ft. **B.** 20 lbs./sq. in.
C. 20 gms./sq. ft. **D.** 1250 gms./sq. ft.
E. 1250 lbs./sq. ft.

302. If 50 dynes of force is exerted upon a free mass of 100
(2.10) grams for 4 secs. the total change in velocity is

A. 2 cms/sec. **B.** 4 cms/sec. **C.** 2/980 cms/sec.
D. 4/908 cms/sec. **E.** 8 cms/sec.

303. If a block weighing 250 lbs. and with a volume of about
(2.10) one cubic ft. is submerged in fresh water it will apparently lose in weight about

A. 1 lb. **B.** 25 lbs. **C.** 32 lbs. **D.** 62.5 lbs.
E. 250 lbs.

304. A car starts from rest and goes down a slope with a
(2.10) constant acceleration of 10 feet per second per second. It takes 5 seconds to get down the hill. The speed of the car at the bottom of the hill is

A. 2 feet per second. **B.** 25 feet per second.
C. 50 feet per second. **D.** 100 feet per second.
E. 125 feet per second.

305 - 307. A car, starting from rest, receives a uniform westward acceleration of 4 feet per second each second.

305. What is the westward velocity of the car in feet per
(2.10) second at the end of the third second of acceleration?

A. 6. **B.** 12. **C.** 36. **D.** 4. **E.** 18.

306. What is the average westward velocity of the car in
(2.10) feet per second during the first three seconds of acceleration?

A. 6. **B.** 12. **C.** 36. **D.** 4. **E.** 18.

307. How far westward in feet does the car travel during
(2.10) the first three seconds of acceleration?

A. 6. **B.** 12. **C.** 36. **D.** 4. **E.** 18.

308. A car starts from rest and moves under the influence
(2.10) of a uniform eastward acceleration of 3 feet per second each second. Which of the following choices gives the number of feet traveled eastward by the car during each of the first four seconds, successively?

A. 1.5, 6.0, 13.5, 24.0. **B.** 3.0, 4.5, 6.0, 7.5.
C. 1.5, 3.0, 4.5, 6.0. **D.** 3, 6, 9, 12.
E. 1.5, 4.5, 7.5, 10.5.

309 - 311. Water flows over a dam at the rate of 600 cubic feet per minute. The vertical distance from the top of the dam to the turbine site below is 80 feet.

309. How much work in foot-pounds is done on one cubic
(2.10) foot of water by the force of gravity during the fall from top to bottom of the dam?

A. 5000. **B.** 80. **C.** 62.5. **D.** 800.
E. 3,000,000.

310. How much work in foot-pounds can the waterfall do
(2.10) in one minute at the turbine site below the dam if all the work possible is performed?

A. 5000. **B.** 48,000. **C.** 600. **D.** 800.
E. 3,000,000.

311. What is the maximum horsepower available at the
(2.10) turbine site?

A. 91. **B.** 540. **C.** 1.1. **D.** 9.1.
E. 3,000,000.

312. A solid having a volume of 8 cubic centimeters weighs
(2.10) 20 gm. in air. How much will it weigh if totally immersed in a liquid having a density of 2 gm. per cubic centimeter?

A. 4 gm. **B.** 10 gm. **C.** 12 gm. **D.** 16 gm.
E. No answer can be given unless the shape of the solid is known.

313. Galileo defines uniformly accelerated motion as motion
(2.10) in which velocity receives, in any time-intervals, increments proportional to the time-intervals. If naturally accelerated motion is defined as the motion of a freely falling body in a vacuum, which of the following is an adequate formulation of Galileo's theory of naturally accelerated motion?

A. A uniformly accelerated motion is a motion in which velocity receives, in any time-intervals, increments proportional to the time-intervals.
B. Naturally accelerated motion is the motion of a freely falling body in a vacuum.
C. Every case of naturally accelerated motion is a case of uniformly accelerated motion.
D. Every case of uniformly accelerated motion is a case of naturally accelerated motion.
E. Either C or D is an adequate formulation.

314. Which of the following statements best accounts for
(2.20) Archimedes' assumption of parts "being continuous" in the postulate?

A. The parts must be continuous if they are to lie evenly.
B. The continuity of parts is verifiable by observations of fluids.
C. The propositions demonstrate the correctness of this assumption.
D. Physical contact of parts is required in order to transmit thrusts.
E. Being continuous, the parts must have the same specific gravity, a necessity for application of the propositions to real situations.

In discussing Sagredo's belief that a falling body suddenly acquires great speed, Salviati considers an experiment in which a heavy object is dropped on a stake from various heights, and the depth to which the stake is driven is measured in each case.

315. The purpose of this procedure is to provide
(2.20)

A. a means of judging the speed acquired by a falling body.
B. a means of judging the time it takes for a body to fall.
C. a means of estimating the height, from which a body falls.
D. a clearer explanation of Galileo's definition of uniformly accelerated motion.
E. a way of investigating the effect of weight on speed.

316. According to Salviati, a small stone placed on top of a
(2.20) large one does not "increase the weight" of the large stone during free and natural fall.
Which of the following is the best statement of the meaning which Galileo intended to convey by this assertion?

A. A body composed of an 8 lb. stone and a 10 lb. stone weighs 10 lbs. during free and natural fall.
B. A body composed of an 8 lb. stone and a 10 lb. stone weighs zero during free and natural fall.
C. A body composed of an 8 lb. stone and a 10 lb. stone falls with the same speed as does the 10 lb. stone alone.
D. A body composed of an 8 lb. stone and a 10 lb. stone falls with a speed intermediate between that of the 8 lb. stone and that of the 10 lb. stone.
E. An 8 lb. stone placed on top of a 10 lb. stone does not press down upon it during free and natural fall.

317. Which of the following is a principle which Salviati
(2.00) must assume when he concludes, from the assertion quoted in question 316, that a heavy body does not fall more rapidly than a light one?

A. One part of a body can affect the motion of another part only by exerting some part of "push" (or pull) upon it.
B. Bodies fall in a vacuum with uniform acceleration, this acceleration being the same for all bodies.
C. The properties of bodies under ideal limiting conditions (e.g., in a vacuum) can be judged on the basis of their observed properties under actual conditions.
D. A small stone, placed on top of a big one, does not tend to fall *more* rapidly than the big stone.
E. The weight of a body varies with its state of motion.

318. Galileo induced the laws of motion governing freely
(2.30) falling bodies from data obtained by rolling objects down inclined planes. He used this experimental method of approach in order to

A. avoid the retarding effect of air friction.
B. make the time-intervals long enough to measure.
C. avoid the disturbing effect of the earth's gravitational field.
D. prove that the greater the angle of inclination, the greater is the increase in acceleration.
E. demonstrate that the value of "g," the acceleration due to gravity, has the same effect whether objects roll down an incline or fall freely.

319. In the equation, F = ma, a definite relationship is
(2.40) expressed symbolically between force, mass and acceleration. From this equation it follows that if force is increased, then

A. mass must also increase if acceleration remains unchanged.
B. both mass and acceleration must increase.
C. mass must increase while acceleration must decrease.
D. mass and acceleration must both decrease.
E. acceleration must decrease if mass remains unchanged.

320. The force of gravitation decreases as the square of the
(2.40) distance between two bodies. Hence, if small particles A, B and C in the same straight line and widely separated are attracted by distant body X, the distance Y and Z both increase since A is attracted the most, B next, and C least. The particles may be liquid or solid.

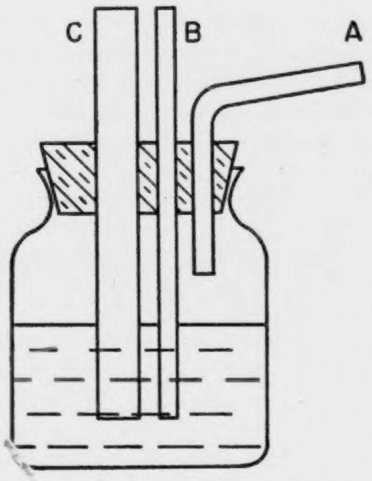
Y Z
X A.....B.....C

This explains why

A. objects weigh less on the moon than on earth.
B. objects weigh less at the poles than at the equator.
C. high tides occur at the same time on opposite sides of the earth.

D. the velocity of the earth is greatest when it is nearest the sun.
E. the earth is flattened at the poles, rather than being perfectly spherical.

Items 321 and 322 refer to the following diagram.



321. (2.40) The bottle is fitted with a three-hole stopper. Tube B has ¼ the diameter of tube C. If air is forced into tube A the water will rise

A. equally high in both tubes.
B. 16 times as high in the small tube.
C. 4 times as high in the small tube.
D. in the small tube only.
E. in the large tube only.

322. (1.30) The explanation of the preceding item follows most directly from the equation

A. P.E. $=$ mgh. **B.** K.E. $= \frac{1}{2}mv^2$.
C. F $=$ ma. **D.** P $=$ hd. **E.** $p_1v_1 = p_2v_2$

For items 323 - 327 indicate the one principle that is most useful in explaining each statement.

KEY

A. The acceleration imparted to a body by a force is proportional to the mass of the body.
B. For every force there is an equal and opposing force.
C. When all forces acting on a body are in equilibrium the body maintains a state of rest or uniform motion.
D. One force properly applied may produce the same result on a body as several separate forces.
E. None of the above principles provides a satisfactory explanation.

323. (2.40) A free balloon does not rise indefinitely but attains a certain altitude which it tends to maintain.

324. (2.40) A towing car stands a lower chance of breaking the tow rope if it starts gradually.

325. (2.40) Rocket propelled aircraft can, in theory, traverse space.

326. (2.40) A glass object is less apt to break when dropped on a fabric rug than on concrete.

327. (2.40) In order to hit a target on a windy day a rifle must be aimed slightly into the wind.

Items 328 - 348. Here a number of general principles are correctly stated. Each general principle is followed by a number of statements. After each item number on the answer sheet **blacken** space

A. if the general principle proves the statement true.
B. if the general principle proves the statement false.
C. if the truth or falsity of the statement cannot be determined, from the general principle.

GENERAL PRINCIPLE: All matter possesses inertia.

328. (2.40) "Stop-and-go" driving will waste gasoline.

329. (2.40) A body which weighs one pound at the equator will weigh more than one pound at the poles.

330. (2.40) A passenger in an automobile may bump his head against the windshield if the driver suddenly applies the brakes.

331. (2.40) A man standing on the rear platform of a train may be jerked off to the rear if the train stops suddenly.

332. (2.40) A boy riding in a swiftly moving train may be surprised to find that, when he throws his orange vertically in the air, it may come down in the lap of an old lady behind him instead of returning to his hands.

GENERAL PRINCIPLE: A force is necessary to change the speed or direction of motion of a body.

333. (2.40) A car on an icy road may not move forward even though the wheels are spinning rapidly.

334. (2.40) A feather and a bullet will fall side by side in a vacuum.

335. (2.40) No force is necessary to keep the earth revolving in its orbit about the sun.

336. (2.40) To keep a car moving with uniform speed on a frictionless straight, level road, no force is necessary.

GENERAL PRINCIPLE: The acceleration given a body is directly proportional to the force applied and inversely proportional to its mass.

337. (2.40) The force necessary to give a 4,000 pound car a velocity of 10 feet per second in one second is four times as great as that necessary to give a 2,000 pound car the same acceleration.

338. (2.40) The pull in the tow rope that is necessary to give a 1,000,000 gram car an acceleration of 1,000 centimeters per second per second is 1,000,000,000 dynes.

339. (2.40) The acceleration of a body is doubled if the mass of the body is doubled.

GENERAL PRINCIPLE: To every action there is an equal and opposite reaction.

340. (2.40) A boy is almost but not quite able to break a rope by tying it to a tree and pulling on it. However, if he secures the help of another boy as strong as he is, both boys can break the rope by pulling the rope between them.

341. (2.40) A boy becalmed in a sailboat can get to shore by having an electric fan blow against the sail.

342. (2.40) The amount of kinetic energy gained by a body falling in a vacuum exactly equals the amount of potential energy possessed by the body when it started to fall.

343. (2.40) When the water is turned on, a fireman may be carried forward with the hose he is pulling.

344. (2.40) A shell pushes a gun backward with the same force that the gun pushes forward on the shell.

GENERAL PRINCIPLE: Every body attracts every other body in the universe.

345. (2.40) On leaving the sun, the tail of a comet will travel ahead of the nucleus.

346. (2.40) A plumb line near a mountain will not point toward the center of the earth.

347. (2.40) The moon rather than the moon and sun together causes the tides.

348. (2.40) Uranus causes irregularities in the orbit of Neptune.

349. (2.40) A pendulum clock may be made to run more slowly by

- **A.** adding more weight to the lower end of the pendulum.
- **B.** taking weight from the lower end of the pendulum.
- **C.** lengthening the pendulum.
- **D.** shortening the pendulum.
- **E.** either of two of the above.

350. (2.40) A person on an airplane moving with *constant velocity* in smooth air may move about normally with no allowance for any motion because

- **A.** the force on the plane is greater than that of the friction of the air through which the plane is flying but is a constant force
- **B.** the time rate of change of velocity of the plane is constant.
- **C.** the vector sum of the forces acting on the plane is zero.
- **D.** there is no vertical component of force.
- **E.** the vertical component of force acting on the plane equals the horizontal component.

For items 351 - 358 select from the key the most appropriate response.

KEY

- **A.** In accord with Newton's First Law of Motion.
- **B.** In accord with Newton's Second Law of Motion.
- **C.** In accord with Newton's Third Law of Motion.
- **D.** In accord with Newton's Universal Law of Gravitation.
- **E.** In accord with none of the above.

351. (2.40) When the ground is slippery it is difficult to walk.

352. (2.40) The harder a batter hits a baseball the farther it will travel.

353. (2.40) "If a horse draws a stone tied to a rope, the horse (if I may say so) will be drawn equally back towards the stone; for the distended rope, by the same endeavor to relax or unbend itself, will draw the horse as much toward the stone, as it does the stone toward the horse, and will obstruct the progress of the one as much as it advances that of the other."

354. (2.40) If all the forces acting on a moving automobile could be removed, the auto would continue to move at a constant velocity.

355. (2.40) A greater force is required to throw a large stone than a small one.

356. (2.40) Tides on earth.

357. (2.40) Centripetal and centrifugal force.

358. (2.40) The force of electrical attraction between the proton and the electron.

Items 359 - 363 refer to applications of certain physical laws. For each item select from the key the law which is most closely involved in explaining the item.

KEY

- **A.** The acceleration imparted to a body by a force is proportional to the magnitude of the force and inversely proportional to the mass of the body.
- **B.** For every force there is an equal and opposing force.
- **C.** A body remains at rest or in uniform motion in a straight line unless acted on by an external force.
- **D.** Every particle in the universe attracts every other particle with a force proportional to the product of the masses and inversely proportional to the square of the distance between them.
- **E.** None of the above laws provides a satisfactory explanation.

359. (2.40) Rocket propelled aircraft can, in theory, traverse space.

360. (2.40) The brakes on a truck are much larger in area than those on a small car.

361. (2.40) Dust and dirt can be removed from a carpet by hanging the carpet up and striking it with a carpet beater.

362. (2.40) Tides occur in the oceans of the earth at intervals which are in step with the lunar day.

363. (2.40) Fenders on a car are protection on a muddy road.

Items 364 - 371. Each item is an application of or is related to one of the laws listed in the key. After each item number on the answer sheet, blacken the one lettered space which indicates the law to which the item refers.

KEY

- **A.** Every body continues its state of rest or of uniform motion in a straight line, unless it is compelled to change that state by a force.
- **B.** The acceleration imparted to a body of given mass is proportional to the force acting and takes place in the same direction as the force applied.
- **C.** To every action there is always opposed an equal reaction; or the mutual actions of two bodies on each other are always equal and opposite
- **D.** Law of Conservation of Energy.
- **E.** None of the above laws.

364. (2.40) When one shoots a gun, he must be careful not to be hurt by the recoil of the gun.

365. (2.40) A car rounding a curve too fast goes off the road on the outside of the curve.

366. (2.40) When a falling object strikes the earth, its energy of motion is converted into an exactly equivalent amount of heat.

367. (2.40) The heavier cars must have more powerful engines if they are to have "pick-up" (acceleration) equal to lighter cars.

368. (2.40) When two bodies are moved so that the distance between them is twice as great as it was before, the force of attraction between them becomes one-fourth of its original value.

369. (2.40) If one jerks a smooth tablecloth quickly enough, it can be removed without disturbing the heavy dishes on it.

370. (2.40) The work output of any machine, increased by the work converted into heat by friction, must always be equal to the input.

371. (2.40) The force with which the sun attracts the earth is exactly equal to the force with which the earth attracts the sun.

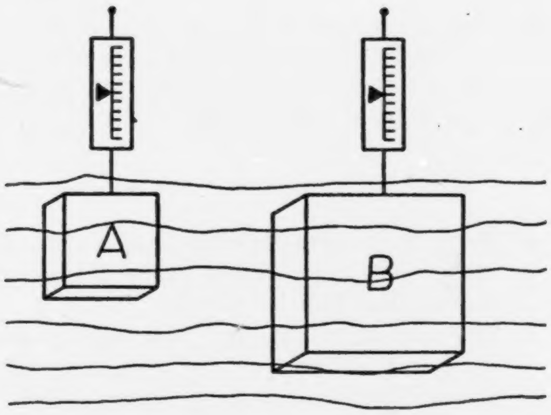
372. (2.40) The effect of a propeller in driving a ship forward is explained most directly

- **A.** as a conversion of potential energy into kinetic.
- **B.** on the basis of Newton's Third Law (action-reaction).
- **C.** as a consequence of the Law of Conservation of Energy.
- **D.** as a conversion of centrifugal force into force of motion in a straight line.

373. (2.40) Which helps to explain the lifting power of an airplane in motion?

- **A.** The momentum of a body increases with its velocity.
- **B.** The acceleration of gravity.
- **C.** A force acting on a surface at an angle may be resolved in two components.
- **D.** The buoyancy of a body is equal to the difference between the weight and that of the displaced air.

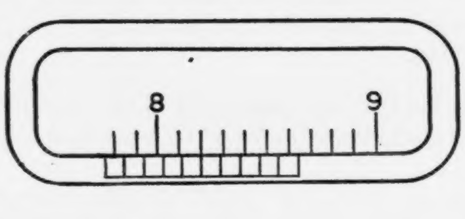
374. (3.00) As shown in the diagram, the two objects of different volume have the same apparent weight when weighed under water.



If they are placed in a vacuum and weighed,

- **A.** they will weigh the same.
- **B.** A will weigh more than B.
- **C.** B will weigh more than A.
- **D.** both will lose all their weight.
- **E.** no comparison between these weights can be made with only the data given.

375. (1.10) The diagram represents a magnified view of a vernier scale with numbers indicating whole centimeters.



The setting shown can be read with significant figures only as

A. 7.75. **B.** 8.65. **C.** 8.25. **D.** 7.65. **E.** 8.20.

Items 376 and 377 refer to this data. A piece of metal weighs 100 gms. in air, 60 gms. in water, and 70 gms. when immersed in gasoline. (The density of water is 1 gm. per cm.^{3})

376. (3.00) The specific gravity of the metal is

A. .6. **B.** 2.5. **C.** 2.3. **D.** 10.0.
E. none of these.

377. (3.00) The volume of gasoline displaced by the metal is

A. 10 cm.^{3} **B.** 30 cm.^{3} **C.** 40 cm.^{3}
D. 50 cm.^{3} **E.** none of these.

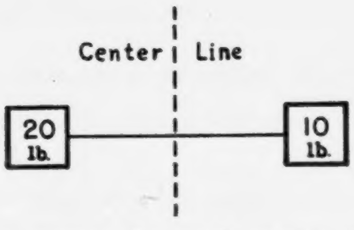
Items 378 - 380 deleted.

381. (3.00) A small steel ball is placed in a tall glass containing a large amount of mercury. Then a quantity of water is poured on top. Which of the following is a correct conclusion?

- **A.** The ball will float on top of the water.
- **B.** The floating ball will rise slightly when the water is added.
- **C.** The mercury will float on top of the water.
- **D.** The ball will sink to the bottom of the container.
- **E.** Adding the water makes the ball sink more deeply in the mercury.

382. (3.00) If two masses of 20 lbs. and 10 lbs., respectively, connected by a rubber band, are stretched apart and released, it follows that

- **A.** the stretching force is not the same for each mass.
- **B.** the larger mass will have the greater acceleration.
- **C.** the masses will meet at a point midway between them.
- **D.** the larger mass will travel the greater distance before striking.
- **E.** the smaller mass will have the greater rate of change in velocity.



383. (3.00) Near the equator, the earth rotates about 1000 miles per hour. If the speed were reduced to 200 miles per hour

- **A.** airplanes flying W to E would make better time.
- **B.** we would fly off the earth's surface.
- **C.** our weight would be affected slightly.
- **D.** the earth's atmosphere would float into outer space.
- **E.** the force of gravity would be lessened.

Items 384 - 388. An object has a weight of one pound when weighed in Chicago with a spring balance. After each item number on the answer sheet, blacken space

- **A.** if the object will weigh considerably more than a pound in the given location.
- **B.** if the object will weigh slightly more than a pound in the given location.

C. if the object will weigh slightly less than a pound in the given location.
D. if the object will weigh considerably less than a pound in the given location.
E. if the object will weigh nothing at all in the given location.

384. (3.00) 2000 miles above the earth's surface.

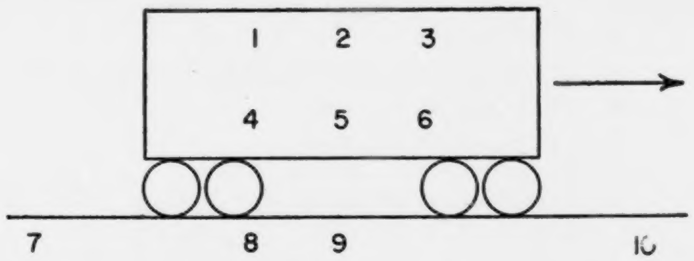
385. (3.00) At the North Pole.

386. (3.00) At the center of the earth.

387. (3.00) At the equator

388. (3.00) At Chicago, if the density of the earth were three times as great as it actually is, but the volume of the earth is the same.

Items 389 - 395.



The diagram shown represents one of the cars in a railroad train traveling at the rate of 88 feet per second in the indicated direction. Points 1 - 6 are in and moving with the train. Assume that air resistance need not be considered. After each exercise number on the answer sheet blacken the one lettered space which designates the correct answer.

389. (3.00) An object is dropped inside the car from point 2. It will land at point

A. 4. **B.** 5. **C.** 6. **D.** 9. **E.** 10.

390. (3.00) An object is dropped outside the car through a window at point 2. It could land at point

A. 7. **B.** 8. **C.** 9. **D.** 10.

391. (3.00) According to the Law of Independence of Motions, at the time the object referred to in exercise 390 hits the ground, it is directly below point

A. 1. **B.** 2. **C.** 3.

392. (3.00) An observer inside the car at point 1 is looking at an object inside the car at point 3. To him, this object appears to be

A. motionless.
B. moving away with uniform motion.
C. moving away with uniform accelerated motion.
D. moving toward him with uniform motion.
E. moving toward him with uniform accelerated motion.

393. (3.00) An observer on the ground at point 10 is looking at an object on the car at point 6 on same level as his eyes.

To this observer this object appears to be

A. motionless.
B. moving away with uniform motion.
C. moving away with uniform accelerated motion.
D. moving toward him with uniform motion.
E. moving toward him with uniform accelerated motion.

394. (3.00) A passenger walks from point 6 to point 4 at a uniform rate. To an observer at point 9 outside the train, his motion would be

A. uniform, to the left, and greater than 88 feet per second.
B. uniform, to the right, and greater than 88 feet per second.
C. uniform, to the left, and less than 88 feet per second.
D. uniform, to the right, and less than 88 feet per second.
E. accelerated, to the left, and less than 88 feet per second.

395. (3.00) A ball thrown vertically upward in the car from point 5 will most probably fall to the floor of the car at point

A. 4. **B.** 5. **C.** 6.

396. (3.00) A body of given mass, m, weighs slightly more at the poles than at the equator, but has zero weight at the center of the earth. Why is this the case?

A. G in the equation $F = G\frac{Mm}{d^2}$ is equal to zero.
B. Mm equals zero at the center of the earth.
C. m is attracted equally in all directions.
D. The weight of an object is directly proportional to its mass.
E. At the center of the earth there is no gravitational attraction.

397. (1.10) The earth is flatter at the poles than at the equator. Which one of the following gives the best explanation of this phenomenon?

A. The earth revolves about the sun.
B. The earth is rotating on its axis.
C. The attraction of the sun produces a bulge at the equator.
D. The interior of the earth is liquid.
E. The expansion of the earth due to heat is greater at the equator.

398. (3.00) A ball rolls down a slope starting from rest. At the end of three seconds, its velocity is 20 cm./sec. At the end of eight seconds, its velocity is 40 cm./sec. What is the average acceleration (in cm./sec.^{2}) from the third to the eighth second?

A. 2.5. **B.** 4.0. **C.** 5.0. **D.** 6.67.
E. none of these.

399. (3.00) Two automobiles are 120 miles apart. If they travel toward each other at the rates of 35 and 45 miles per hour, in how many hours will they meet?

A. 2½. **B.** 2. **C.** 1¾. **D.** 1½. **E.** 1¼.

Items 400 - 401. Imagine a football filled with some very dense material so that it weighed 50 lbs; further, imagine it had been hung on a spring balance in an elevator, the cable of which broke so that the elevator fell freely.

400. (3.00) The spring balance

A. would still read 50 lbs.
B. would read 32 lbs. less than 50.
C. would read 0 lbs.
D. would read more than 50 lbs.
E. reading would be entirely unpredictable.

401. If it were possible to kick the football horizontally while
(3.00) the elevator was falling freely,

A. the sensation would be similar to kicking the ball outside.
B. the effect would be the same as kicking an empty football.
C. it would require more than 50 lbs. of force to move it horizontally.
D. no force would be required for a horizontal kick.
E. no prediction can be made of what would happen.

Items 402 - 404 refer to the following: A glass bottle stopper weighs 80 gm. in air but only 60 gm. when immersed in water. When immersed in alcohol the buoyancy force is 15 gm.

402. The volume of alcohol displaced is
(3.00)

A. 20 cm.^{3} **B.** 15 cm.^{3} **C.** 65 cm.^{3}
D. 35 cm.^{3} **E.** none of these.

403. The density of the stopper is
(3.00)

A. 1.25 gm./cm.^{3} **B.** 5.00 gm./cm.^{3}
C. .75 gm./cm.^{3} **D.** 3.00 gm./cm.^{3}
E. none of these.

404. The weight of the alcohol displaced is
(3.00)

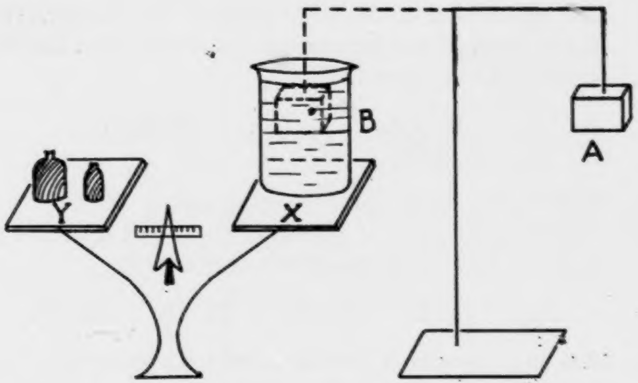
A. 5 gm. **B.** 65 gm. **C.** 15 gm. **D.** 45 gm.
E. none of these.

405. A one pound weight fell from a building, freely, so
(3.00) that just as it struck the ground it had a kinetic energy of 5120 ft. poundals. Before it fell it had a potential energy of

A. 32 ft. poundals. **B.** 160 ft. poundals.
C. 5120 ft. poundals. **D.** 10,250 ft. poundals.
E. none of these.

406. In the preceding item, the height from which the
(3.00) weight fell is

A. 64 ft. **B.** 80 ft. **C.** 128 ft. **D.** 320 ft.
E. none of these.



407. When the metal cube is in position A and supported
(3.00) by a chain fastened to the support rod, the scales with the beaker of water are in balance. When the arm of the support rod is swung around so as to immerse the cube but spill no water,

A. pan Y will go down. **B.** pan X will go down.
C. the scales will stay in balance.
D. the scales will read the same as if the cube were resting on the bottom of the beaker.

Items 408 - 411 refer to observations made at sea level. Select from the key the change which would occur if these were made at the surface of the moon.

KEY

A. Increase. **B.** Decrease but not to zero.
C. Remain unchanged.
D. Become zero or inoperative.
E. No basis for prediction.

408. The weight of an airplane.
(3.00)

409. The presence of sedimentary rock.
(1.22)

410. The barometric pressure.
(1.10)

411. The velocity of sound.
(1.10)

412. The density of sea water is greater than fresh water.
(3.00) A ship loaded at a fresh water port upon reaching salt water will

A. experience a decrease in total buoyant force.
B. ride higher in the water.
C. settle lower in the water.
D. displace a greater weight of water.
E. experience no change in the depth at which she rides.

413. A corked liter bottle weighs 940 gms. When placed in
(3.00) alcohol which has a specific gravity of .81, the bottle

A. will sink because it would be full of water and water is more dense than alcohol.
B. will float because a liter bottle would give a buoyancy force of 1000 gms.
C. will float because the bottle will displace 1000 cm.^{3} of alcohol.
D. will sink because it weighs more than the weight of alcohol displaced.
E. will sink because the bottle only displaces 810 cm.^{3} of alcohol.

For items 414 - 418 consider the following statements:

Plane 1 when equipped with jet propulsion units to assist during takeoff is able to attain flying speed of 120 mph 40 seconds after the application of full throttle. Plane 2, similar to plane 1 but not equipped with the auxiliary jets, requires 60 seconds of full power to gain the speed of 120 mph. Assuming that both planes gain speed uniformly, evaluate the statements according to the key.

KEY

A. The statement is true. **B.** The statement is false.
C. No marked degree of truth or falsity can be indicated.

414. Both planes would travel the same distance during
(3.00) takeoff.

415. Plane 1 attained greater velocity during takeoff than
(3.00) Plane 2.

416. The planes are of equal efficiency.
(1.20)

417. Plane 2 travelled 1 mile from the time full power was
(3.00) applied until attaining takeoff speed.

418. (3.00) The acceleration of Plane 2 was equal to the acceleration of Plane 1.

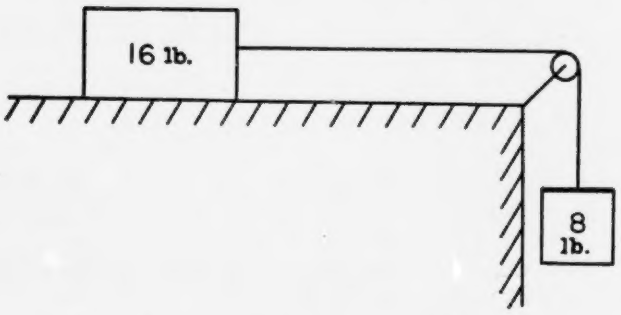
419. (3.00) Automobile 1 goes around a curve at 30 mph. Automobile 2 of equal weight goes around the same curve at 90 mph. The force causing car 2 to tend to leave the road would be

- **A.** equal to that of car 1.
- **B.** three times that of car 1.
- **C.** six times that of car 1.
- **D.** nine times that of car 1.
- **E.** more than nine times that of car 1.

420. (3.00) At which of the following positions would the weight of an object be the least?

A. 2000 miles above the surface of the earth.
B. At the North Pole. **C.** At the equator.
D. At the center of the earth.

421. (3.00) A 16 lb. mass on a horizontal surface is connected by a cord which passes over a pulley to an 8 lb. mass which hangs vertically. All frictional forces and the inertia of the pulley can be disregarded.



The acceleration of the system in ft./sec.^{2} is

A. 0.5. **B.** 0.33. **C.** 16. **D.** 10.67.
E. none of these.

422. (3.00) A steel sphere suspended by a wire of negligible size was weighed in turn in water (specific gravity 1.0), in alcohol (specific gravity 0.81), and in gasoline (specific gravity 0.72). Its apparent weight was

A. greatest in water. **B.** greatest in alcohol.
C. greatest in gasoline.
D. the same in all the liquids.
E. not related to the data given.

423. (3.00) Two objects of different volume have the same apparent weight when weighed under water. If they are placed in a vacuum and weighed

- **A.** they will weigh the same.
- **B.** the larger will weigh more than the smaller.
- **C.** the smaller will weigh more than the larger.
- **D.** both will lose all their weight.
- **E.** no comparison between these weights can be made with only the data given.

Items 424 - 427 refer to the following data. A car of mass 4400 pounds started from rest and in 10 seconds acquired a velocity of 80 feet per second under the influence of a uniform acceleration force. Neglect friction, air resistance, and other losses.

424. (3.00) The uniform accelerating force, in pounds, was

A. 550. **B.** 1100. **C.** 4400. **D.** 35,200.
E. 140,800.

425. (3.00) During this time-interval, the distance, in feet, travelled by the car was

A. 80. **B.** 160. **C.** 400. **D.** 800. **E.** 1600.

426 (3.00) The work, in foot-pounds, done in accelerating the car was

A. 800. **B.** 5500. **B.** 880,000. **D.** 444,000.
E. 14,080,000.

427. (2.10) The average horsepower at which the work was done was

A. 10. **B.** 160. **C.** 80. **D.** 800. **E.** 2560.

428. (3.00) Bullets from two revolvers are fired with the same velocity. The bullets from one are twice as heavy as those from the other; the revolver firing the heavier bullet weighs three times as much as the other. The recoil of (momentum imparted to) the heavier revolver will be

- **A.** 2/3 of the recoil of the lighter one.
- **B.** 3/2 of the recoil of the lighter one.
- **C.** twice the recoil of the lighter one.
- **D.** three times the recoil of the lighter one.
- **E.** six times the recoil of the lighter one.

429. (3.00) In considering the lifting forces acting on a balloon in the atmosphere, it is *necessary* to account for the

- **A.** additional weight imparted by the atmosphere above the balloon.
- **B.** downward force imparted by the atmospheric pressure acting on the lower surface of the balloon.
- **C.** the difference between the pressure of the atmosphere and the pressure of the gas in the balloon.
- **D.** the difference between the density of the balloon and the density of the air.
- **E.** chemical properties possessed by the gas with which the balloon is filled.

430. (3.00) If an object weighs 60 lbs. on the surface of the earth, the same object on a planet with twice the earth's diameter and twice the earth's mass would weigh

A. 15 lbs. **B.** 30 lbs. **C.** 60 lbs. **D.** 120 lbs.
E. 240 lbs.

431. (3.00) The acceleration of a freely falling body near the earth's surface has been measured as 980 cm./sec.^{2} If the earth had the same mass, but had twice the diameter it now has, this figure would be

A. 980 cm./sec.^{2} **B.** 1960 cm./sec.^{2}
C. 490 cm./sec.^{2} **D.** 245 cm./sec.^{2}
E. 122½ cm./sec.^{2}

432. (3.00) A cylindrical tube of 2 square cms. cross section is floating upright in a liquid of density 1.2 gms. per cubic cm. with 10 cms. of its length submerged. The force on the bottom of the tube is

A. 12 gms. **B.** 20 gms. **C.** 24 gms. **D.** 6 gms.
E. 14.4 gms.

433. (3.00) A puck whose mass is one pound is traveling 10 ft. per sec. when it hits a 2-pound puck, situated directly in its path. If they stick together on impact, the velocity of the combined masses is

A. 5 ft./sec. **B.** $\sqrt{50}$ ft./sec. **C.** 3 and ⅓ ft./sec.
D. $\sqrt{10}$ ft./sec. **E.** 2.5 ft./sec.

An automobile weighing 3200 lbs. starts from rest and picks up speed uniformly for 15 secs. At the end of that time it has gone 60 yards.

434. The average speed during the 15 secs. is
(3.00)

A. 12 ft./sec. **B.** 108 ft./sec. **C.** 24 ft./sec.
D. 18 ft./sec. **E.** 6 ft./sec.

435. The final speed at the end of 15 secs. is
(3.00)

A. 12 ft./sec. **B.** 60 ft./sec. **C.** 48 ft./sec.
D. 30 ft./sec. **E.** 24 ft./sec.

436. The acceleration of the car is
(3.10)

A. 0.8 ft./sec./sec. **B.** 1.6 ft./sec./sec.
C. 2 ft./sec./sec. **D.** 3.2 ft./sec./sec.
E. 4 ft./sec./sec.

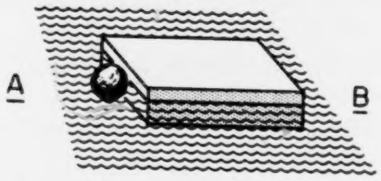
437. The force accelerating the car must have been
(3.00)

A. 32 lbs. **B.** 160 lbs. **C.** 200 lbs.
D. 400 lbs. **E.** 320 lbs.

438. The tangent of the angle which the resultant makes with the east direction is
(3.00)

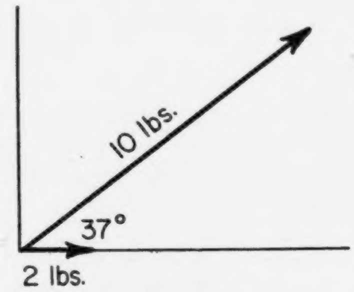
A. 0.5. **B.** 1.2. **C.** 0.6 **D.** 1. **E.** 1.513.

439. Water slowly dissolves the camphor particle which is stuck at the end of the floating piece of wood. If dissolved camphor decreases the surface tension of water, the piece of wood will probably
(3.00)



A. move towards *A*. **B.** spin around in circles.
C. move toward *B*. **D.** remain stationary.

Two forces are acting at a point, 2 lbs. due east and 10 lbs. 37° north of east.



sin 37° = 0.6
cos 37° = 0.8

440. The total effective force east is
(3.00)

A. 8 lbs. **B.** 6 lbs. **C.** 2 lbs. **D.** 10 lbs.
E. 12 lbs.

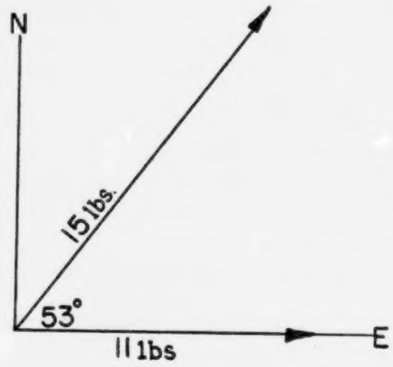
441. The effective force north is
(3.00)

A. 0 lbs. **B.** 6 lbs. **C.** 8 lbs. **D.** 6 and ⅔ lbs.
E. 8½ lbs.

442. The resultant force is
(3.00)

A. $\sqrt{136}$ lbs. **B.** 10 lbs. **C.** $\sqrt{128}$ lbs.
D. 12 lbs. **E.** $\sqrt{150}$ lbs.

Two forces are acting at a point, 11 lbs. due east and 15 lbs. 53° north of east.



sin 53° = 0.8
cos 53° = 0.6

443. The total effective force east is
(3.00)

A. 11 lbs. **B.** 9 lbs. **C.** 20 lbs. **D.** 12 lbs.
E. 23 lbs.

444. The effective force north is
(3.00)

A. 12 lbs. **B.** 9 lbs. **C.** 0 lbs. **D.** 3 lbs.
E. 4 lbs.

445. The resultant force is
(3.00)

A. $\sqrt{346}$ lbs. **B.** 32 lbs. **C.** 8 lbs. **D.** 26 lbs.
E. $\sqrt{544}$ lbs.

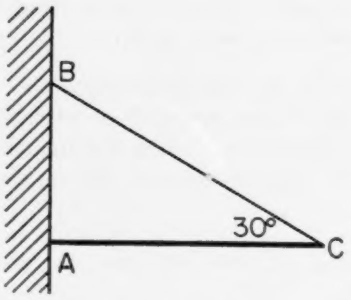
446. The tangent of the angle which the resultant makes with the east direction is
(3.00)

A. 15/11. **B.** 11/15. **C.** 1.33. **D.** 0.75.
E. 0.6.

447. If a force of 50 lbs. operating in a direction parallel to a certain floor is necessary to push along the floor a box loaded to weigh 200 lbs., which of the following statements is true?
(3.00)

A. The force necessary to maintain the motion of the box is independent of the load.
B. The same force is necessary to produce motion of the same box along any horizontal floor.
C. The required force is less if applied directly by the hands than if by means of a rope.
D. A force of 25 lbs. will be sufficient for the purpose if the box is loaded to weigh only 100 lbs.
E. A force of much more than 100 lbs. will be needed to keep the box in motion if the load is made 400 lbs.

448. A uniform shelf 2 feet wide and weighing 10 lbs. is attached to a wall by a hinge at A and a wire from C to B.
(3.00)



sin 30° = 0.5
cos 30° = 0.866

Using the Law of Moments we find the pull in CB to be

A. 10 lbs. **B.** 10/0.966 lbs. **C.** 8.66 lbs.
D. 2 lbs. **E.** 15.4 lbs.

449. (3.00) Two bodies of different mass, placed on a frictionless surface, are acted on by like forces for the same length of time. At the end of the time the body of greater mass will have

A. the greater velocity. **B.** the greater acceleration.
C. the smaller momentum.
D. the same momentum as the body of lesser mass.
E. the greater momentum.

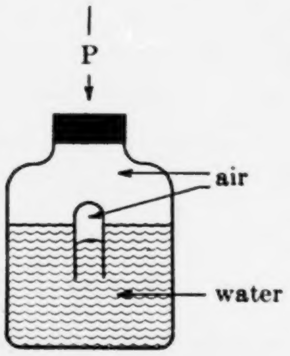
450. (3.00) When thrown into a fresh-water lake, a tightly corked bottle of external volume 750 cu. cms. weighing 500 gms. will

A. float partly submerged. **B.** sink to the bottom.
C. sink part way to the bottom.
D. sink just level with the surface.
E. sink if there is an increase in the atmospheric pressure.

451. (3.00) A tire pressure gauge reads 45 just after application to the tire. To get the actual pressure in the tire, one should

A. add to this the atmospheric pressure.
B. subtract from this the atmospheric pressure.
C. add 30. **D.** subtract 30. **E.** take this value.

452. (3.00) Pushing down on the piston P of the diagram causes the test tube to sink to the bottom of the containing vessel. The experiment probably would not work if



A. gasoline were used instead of water.
B. hydrogen were used instead of air.
C. gases were no more compressible than liquids.
D. the apparatus were heated to 90°C.
E. the atmospheric pressure were very low when the apparatus was assembled.

453. (2.10) The horsepower developed by a man weighing 165 lbs., who in 4 secs. runs up 12 stairsteps, each rising 10 ins., is

A. 0.75. **B.** 0.6. **C.** 0.375. **D.** 0.3. **E.** 1.

454. (3.00) A uniform plank 12 feet long, weighing 20 lbs., is balanced on a sawhorse at its center. If a weight of 40 lbs. is placed on the left end of the plank, it will be necessary, in order to keep it balanced, to move the plank to the right

A. 4 ft. **B.** 3 ft. **C.** 2 ft. **D.** 3 and 3/7 ft.
E. 1 ft.

455. (3.00) Any liquid will wet a solid

A. if the adhesive force is greater than the cohesive force.
B. always. **C.** if the solid is perfectly clean.
D. if the cohesive force is greater than the adhesive force.
E. if the liquid has a large surface tension.

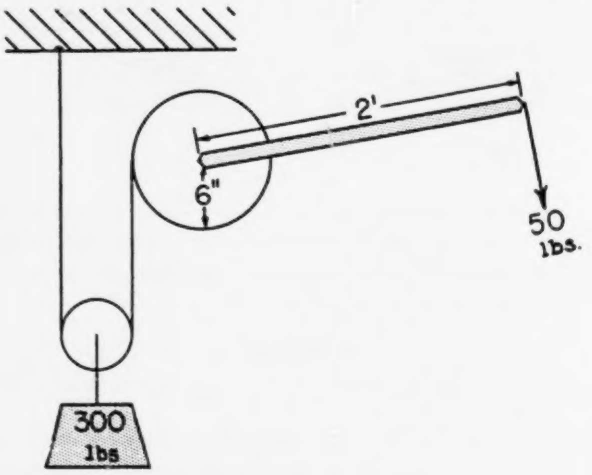
456. (3.00) A uniform meter stick weighing 240 grams can be balanced by a weight of 240 grams at the 100 centimeter mark if the fulcrum is placed at the point marked

A. 75 cms. **B.** 60 cms. **C.** 50 cms.
D. 40 cms. **E.** 80 cms.

457. (3.00) A block of mass 2 lbs. slides down a plane 2 ft. high and 10 ft. long. If one-half the energy is wasted in overcoming friction, the velocity at the bottom is approximately

A. 40 ft./sec. **B.** 5 ft./sec. **C.** 20 ft./sec.
D. 10 ft./sec. **E.** 8 ft./sec.

458 - 460. A weight of 300 lbs. is attached to a pulley of negligible weight which is raised by means of a drum of 6 inches radius with a crank handle 2 ft. long. It requires a force of 50 lbs. at the end of the crank to raise the weight.



458. (3.00) The ideal mechanical advantage is

A. 8. **B.** 4. **C.** 4π. **D.** 12. **E.** 9.

459. (3.00) The practical mechanical advantage is

A. 2. **B.** 8. **C.** 6. **D.** 2π. **E.** 3.

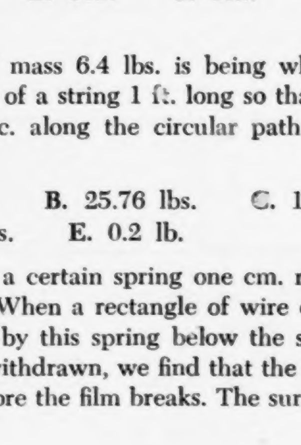
460. (3.00) The efficiency is

A. 66⅔%. **B.** 50%. **C.** 87%. **D.** 92%.
E. 75%.

461. (3.00) A stone of mass 6.4 lbs. is being whirled horizontally on the end of a string 1 ft. long so that it has a velocity of 2 ft./sec. along the circular path. The pull in the string is

A. 0.8 lb. **B.** 25.76 lbs. **C.** 12.88 lbs.
D. 3.22 lbs. **E.** 0.2 lb.

462. (3.00) To stretch a certain spring one cm. requires a force of 98 dynes. When a rectangle of wire of width 2 cms. is suspended by this spring below the surface of a liquid and then withdrawn, we find that the spring is stretched 2 cms. before the film breaks. The surface tension of the liquid is



A. 98 dynes/cm. **B.** 54 dynes/cm.
C. 196 dynes/cm. **D.** 49 dynes/cm.
E. 396 dynes/cm.

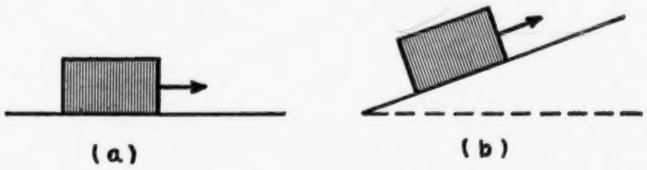
463. (3.00) The barometric pressure is such as to exert a pressure of 1000 gms. per square cm. on the surface of a pond.

At a depth of 2000 cms. below the surface the pressure, as compared to that at a depth of 1000 cms., is approximately

A. twice as much. **B.** three times as much.
C. 1.5 times as much. **D.** 4 times as much.

464. (3.00) An object weighs 20 gms. in air, 15 gms. in water, and 18 gms. in a second liquid. The density of the second liquid is

A. 3 gms./cu. cm. **B.** 0.6 gms./cu. cm.
C. 0.8 gms./cu. cm. **D.** 2 gms./cu. cm.
E. 0.4 gms./cu. cm. **F.** ⅔ gms./cu. cm.



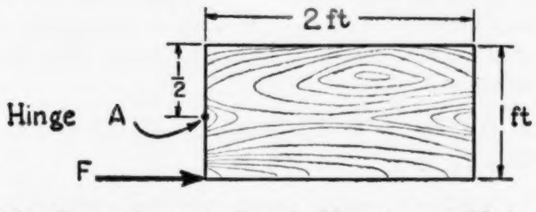
465. (3.00) A heavy wooden block is being drawn over a steel plate, (a) with the plate horizontal, (b) with the plate inclined. The force required to overcome friction in case (b), as compared to case (a), is

A. the same. **B.** greater. **C.** less.
D. greater for some angles, less for others.

466. (3.00) A cylinder is floating upright in a jar of water. If a considerable amount of liquid of specific gravity 0.8 is added to the water and the cylinder still floats upright,

A. the cylinder has less of its length submerged.
B. the force on the bottom of the cylinder is less.
C. a greater weight of liquid is displaced.
D. the pressure on the bottom of the cylinder is the same as before.
E. the force on the bottom of the cylinder is greater.

Items 467 - 469. A uniform piece of board weighing 10 lbs. is 2 ft. long and 1 ft. wide. It is held (free to swing in a vertical plane) by a hinge at A.



467. (3.00) The force F required to hold it in equilibrium in the position shown is

A. 10 lbs. **B.** 5 lbs. **C.** 20 lbs. **D.** 7.5 lbs.

468. (3.00) The force at the hinge A is

A. 30 lbs. **B.** $\sqrt{500}$ lbs. **C.** $\sqrt{30}$ lbs.
D. 15 lbs. **E.** $\sqrt{400}$ lbs.

469. (3.00) The force at the hinge makes an angle with the horizontal whose tangent is

A. 1. **B.** 0.3. **C.** 1.72. **D.** 0.5. **E.** 0.1.

470. (3.00) A body weighs 100 gms. in air and 90 gms. in water. In a liquid of specific gravity 0.7 it will weigh

A. 70 gms. **B.** 63 gms. **C.** 14 4 gms.
D. 107 gms. **E.** 93 gms.

471. (3.00) Standing on a cliff jutting over a lake 200 ft. below, several boys throw stones of the same weight at the same speed but at different angles with the horizontal. Neglecting the effects of air resistance,

A. the stones all reach the water at the same time.
B. the stone thrown horizontally reaches the water first.
C. the stone thrown vertically downward has the least energy.
D. the stones all reach the water with the same kinetic energy.
E. the last stone to strike has the most energy.

A plane 4 ft. long is inclined at angle of 30° to the horizontal. A hollow cylinder and sphere, each of one inch radius and of mass 1 lb. and 5 lbs., respectively, are released from the top of the inclined plane and allowed to roll down. The moment of inertia of a hollow cylinder is MR^2 and of a sphere is $\frac{2}{5}MR^2$.

472. (3.00) The potential energy of the hollow cylinder at the top of the inclined plane is

A. 1 ft. lb. **B.** 2 ft. lbs. **C.** 4 ft. lbs.
D. 10 ft. lbs. **E.** 32 ft. lbs.

473. (3.00) The potential energy of the sphere at the top of the inclined plane is

A. 1 ft. lb. **B.** 2 ft. lbs. **C.** 4 ft. lbs.
D. 10 ft. lbs. **E.** 32 ft. lbs.

474. (3.00) The linear velocity of the hollow cylinder at the bottom of the inclined plane is

A. $\sqrt{2}$ ft./sec. **B.** 2 ft./sec. **C.** 8 ft./sec.
D. $8\sqrt{2}$ ft./sec. **E.** $8\sqrt{\frac{10}{7}}$ ft./sec.

475. (3.00) The linear velocity of the sphere at the bottom of the inclined plane is

A. $\sqrt{2}$ ft./sec. **B.** 2 ft./sec. **C.** 8 ft./sec.
D. $8\sqrt{2}$ ft./sec. **E.** $8\sqrt{\frac{10}{7}}$ ft./sec.

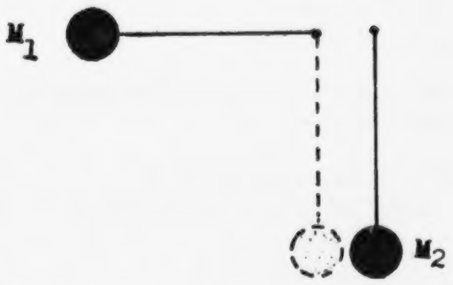
476. (3.00) The angular velocity of the hollow cylinder at the bottom of the plane is

A. 96 radians/sec. **B.** $96\sqrt{\frac{10}{7}}$ radians/sec.
C. $96\sqrt{2}$ radians/sec. **D.** 8 radians/sec.
E. $8\sqrt{\frac{10}{7}}$ radians/sec.

477. (3.00) The angular velocity of the sphere at the bottom of the plane is

A. 96 radians/sec. **B.** $96\sqrt{\frac{10}{7}}$ radians/sec.
C. $96\sqrt{2}$ radians/sec. **D.** 8 radians/sec.
E. $8\sqrt{\frac{10}{7}}$ radians/sec.

A mass $m_1 = 1$ lb., held by a string 4 ft. long, is allowed to swing from a horizontal to a vertical position. It then strikes $m_2 = 1$ lb., which is held by a string of the same length. After impact the two masses stick together.



478. The speed of m_1 just before impact is
(3.00)

A. 1 ft./sec. **B.** 2 ft./sec. **C.** 8 ft./sec.
D. 16 ft./sec. **E.** 32 ft./sec.

479. The speed of m_1 and m_2 just after impact is
(3.00)

A. 1 ft./sec. **B.** 2 ft./sec. **C.** 8 ft./sec.
D. 16 ft./sec. **E.** 32 ft./sec.

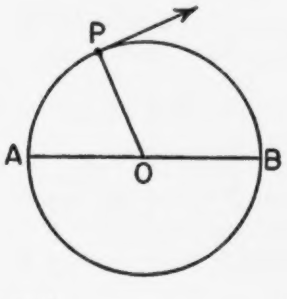
480. The two masses swing to a height above their lowest
(3.00) position of

A. 1 ft. **B.** 2 ft. **C.** 8 ft. **D.** 16 ft.
E. 32 ft.

481. When m_1 strikes m_2, the energy lost is
(3.00)

A. 1 ft. lb. **B.** 2 ft. lb. **C.** 8 ft. lb.
D. 16 ft. lb. **E.** 32 ft. lb.

P is moving uniformly around a circle of 2 ft. radius. It coincides at A and B with a simple pendulum swinging between these points. The period is 3 sec.



482. The frequency is
(3.00)

A. 1. **B.** $\frac{1}{2}$. **C.** $\frac{1}{3}$. **D.** $\frac{1}{4}$. **E.** $\frac{1}{5}$.

483. The angular velocity of P in radians per second is
(3.00)

A. 2π. **B.** π. **C.** $\frac{1}{2}\pi$. **D.** $\frac{1}{3}\pi$. **E.** $\frac{2}{3}\pi$.

484. The linear velocity of P in feet per second is
(3.00)

A. 4π. **B.** 3π. **C.** π. **D.** $\frac{4}{3}\pi$. **E.** $\frac{3}{4}\pi$.

485. The velocity of the pendulum at point A in feet per
(3.00) second is

A. 2π. **B.** π. **C.** 0. **D.** 3.4π. **E.** 2.3π.

486. The velocity of the pendulum at the point 0 in feet per
(3.00) per second per second is

A. 2π. **B.** $\frac{4}{3}\pi$. **C.** 4π. **D.** 0. **E.** π.

487. The acceleration of the pendulum at the point A in feet
(3.00) per second per second is

A. 0. **B.** $\sqrt{\frac{\pi}{2}}$. **C.** $\frac{32}{9}\pi^2$. **D.** $\frac{9}{8}\pi^2$. **E.** $\frac{8}{9}\pi^2$.

488. The acceleration of the pendulum at the point 0 in feet
(3.00) per second per second is

A. 0. **B.** $\sqrt{\frac{\pi}{2}}$. **C.** $\frac{32}{9}\pi^2$. **D.** $\frac{9}{8}\pi^2$. **E.** $\frac{8}{9}\pi^2$.

489. The length of the pendulum in feet is
(3.00)

A. $\frac{8}{\pi^2}$. **B.** $\frac{9}{\pi^2}$. **C.** $\frac{96}{\pi^2}$. **D.** $\frac{72}{\pi^2}$. **E.** $\frac{36}{\pi^2}$.

490. A 160-pound acrobat falls 16 feet into a net. The net
(3.00) tosses him back with an initial velocity equal to that with which he hit it. What is the average force exerted on him by the net?

A. 16 pounds. **B.** 32 pounds. **C.** 64 pounds.
D. 160 pounds.
E. Impossible to determine from above information.

491. A car having a mass of 2400 pounds starts from rest.
(3.00) What unbalanced force in pounds is required to give the car an acceleration of 1.6 feet per second each second?

A. 32. **B.** 120. **C.** 60. **D.** 1500. **E.** 3840.

492. A car of mass 3200 pounds starts from rest and, under
(3.00) the influence of a uniform accelerating force, attains a northward velocity of 24 feet per second by the action of the force for 8 seconds. What is the magnitude of the uniform northward acceleration force which is acting on the car? (Answer in pounds).

A. 150. **B.** 400. **C.** 300. **D.** 76,800.
E. 9600.

493 - 494. An elastic ball, whose mass is ½ pound, strikes an immovable elastic wall. The speed of the ball before impact is 48 feet per second toward the wall, and after impact is 48 feet per second away from the wall, the motion of the ball being always perpendicular to the wall. The ball is in contact with the wall for one hundredth of a second.

493. What acceleration, in feet per second per second, does
(3.00) the ball experience by the impact?

A. 48. **B.** 96. **C.** 9600. **D.** 4800. **E.** 0.

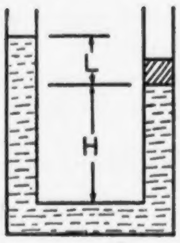
494. According to Newton's axioms, what force in pounds
(3.00) does the ball exert on the wall while the two are in contact?

A. 0. **B.** 150. **C.** 300. **D.** 4800. **E.** 1.5.

495. A car of mass 3200 pounds starts from rest and acquires
(3.00) a westward speed of 60 feet per second under the action of a uniform accelerating force. How much work in foot pounds was done in accelerating the car?

A. 192,000. **B.** 180,000. **C.** 360,000.
D. 5,760,000. **E.** 11,520,000.

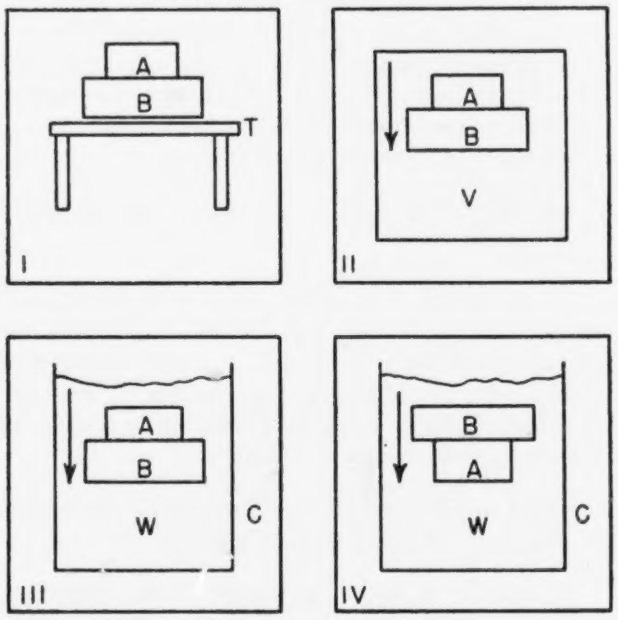
496. The diagram represents a U-tube having a cross-
(3.00) sectional area of *A* square centimeters and partially filled with oil of density *d* gm per cubic centimeter. A solid which fits the tube tightly but which slides in the tube without friction is placed on the oil in the right-hand arm and comes to rest when the oil is *L* centimeters higher in one arm than in the other, and *L* + *h* centimeters higher than in the horizontal portion of the tube. The weight of the solid is equal to



A. ALd. **B.** L^3d. **C.** ALd + Ahd.
D. ALd — Ahd. **E.** None of these.

497. (3.00) The oil levels (see diagram) can be made equal again

A. if any solid of density equal to that of the first solid, and fitting the tube tightly, is placed on the left-hand surface.
B. if any solid of volume equal to that of the first solid, and fitting the tube tightly, is placed on the left-hand surface.
C. if a solid considerably less dense than the oil is placed on the first solid.
D. if sufficient oil is removed from the left arm of the U-tube.
E. if a proper quantity of liquid less dense than oil and insoluble in oil is poured in the left arm.



Explanation: In each of the above figures, A represents a block of lead and B a block of wood; A and B are bound together by very light but strong wire. In figure I, T is a table-top upon which B rests. In figure II, the body AB is free to fall in a vacuum V. In figures III and IV, C represents a container of water (W), in which the body AB is free to fall.

498. (3.00) In the situation represented by figure I, which of the following is a force exerted upon the block of lead A? (*One* or *two* correct answers).

A. The weight of A.
B. A downward force due to the height of B.
C. An upward thrust exerted by B.
D. All of the above.
E. None of the above.

499. (3.00) In the situation represented by figure I, which of the following is a force exerted upon the block of wood B? *(One* or *two* correct answers).

A. A downward thrust due to the weight of A.
B. The weight of B.
C. An upward thrust due to T.
D. All of the above.
E. None of the above.

500. (3.00) In the situation represented by figure II, which of the following is true?

A. A is acted upon by its own weight, the weight of B, and an upward thrust exerted by B; B is acted upon by its own weight and the weight of A.
B. A is acted upon by its own weight and an upward thrust exerted by B; B is acted upon by its own weight and the weight of A.
C. A is acted on by its own weight and the weight of B; B is acted on by its own weight and the weight of A.
D. A is acted on by its own weight alone; B is acted on by its own weight and that of A.
E. A is acted on only by its own weight, B is acted on only by its own weight.

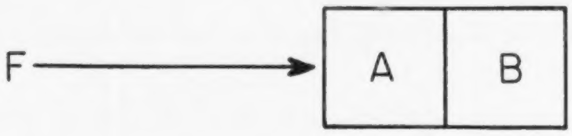
501. (3.00) In the situation represented by figure III, which of the following is a force exerted upon A?

A. A downward force exerted by B, and equal to the weight of B.
B. A downward force exerted by B, and equal to the weight of B minus the weight of a body of water equal in volume to B.
C. An upward thrust exerted by B, equal to the weight of A.
D. An upward thrust exerted by B, less than the weight of A.
E. None of the above.

502. (3.00) In the situation represented by figure IV, which of the following is a force exerted upon A?

A. A downward thrust exerted by B, and equal to the weight of B.
B. a downward thrust exerted by B, and equal to the weight of B minus the weight of a body of water equal in volume to B.
C. An upward force exerted by B, equal to the weight of A.
D. An upward force exerted by B, less the weight of A.
E. None of the above.

503. (3.00) Suppose that bodies A and B are in contact with one another, and either both at rest or else moving in the same direction with the same speed, so that they remain in contact.



If an impressed motive force, F, is applied to body A, then *A will exert a force* against B

A. equal in magnitude, and in the same direction, as F.
B. equal in magnitude, and in the opposite direction to F.
C. only if B is not subject to another force which accelerates it, in the direction of the force F, at least as much as F accelerates A.
D. only if B is not subject to another force which is equal in magnitude, and in the same direction, as F.
E. only if B is not subject to another force, equal in magnitude, and opposite in direction to F.

504. (3.00) If two imperfectly elastic bodies, each of mass 1000 gm, and moving in opposite directions both with speeds of 10 cm./sec., collide head on, then after they rebound from the collision

- **A.** the total momentum of the two bodies will be 20,000 gm-cm./sec.; their total kinetic energy will be 100,000 ergs.
- **B.** the total momentum of the two bodies will be 20,000 gm-cm./sec.; their total kinetic energy will be between zero and 100,000 ergs.
- **C.** the total momentum of the two bodies will be zero; their total kinetic energy will be between zero and 100,000 ergs.
- **D.** the total momentum of the two bodies will be 20,000 gm-cm./sec.; their total kinetic energy will be zero.
- **E.** the total momentum of the two bodies and their total kinetic energy will both be zero.

505. (3.00) If two imperfectly elastic bodies, each of mass 1,000 gm, and moving in opposite directions, both with speed of 10 cm./sec., collide head on, then at the moment when the bodies are most compressed and about to rebound

- **A.** the total momentum of the two bodies will be 20,000 gm-cm./sec.; their total kinetic energy will be between zero and 100,000 ergs.
- **B.** the total momentum of the two bodies will be zero; their total kinetic energy will be between zero and 100,000 ergs.
- **C.** the total momentum of the two bodies will be 20,000 gm-cm./sec.; their total kinetic energy will be zero.
- **D.** the total momentum of the two bodies and their total kinetic energy will both be zero.
- **E.** None of the above will be the case.

506. (3.00) If two perfectly inelastic bodies, each of mass 1000 gm. and moving in opposite directions, both with speeds of 10 cm./sec., collide head on, then after the collision

- **A.** the total momentum and the total kinetic energy of the two bodies will both be zero.
- **B.** the total momentum of the two bodies will be zero, their total kinetic energy will be 100,000 ergs.
- **C.** the total momentum of the two bodies will be 20,000 gm-cm./sec.; their total kinetic energy will be zero.
- **D.** the total momentum of the two bodies will be 20,000 gm-cm./sec.; their total kinetic energy will be 100,000 ergs.
- **E.** the total momentum of the two bodies will be 20,000 gm-cm./sec.; their total kinetic energy will be between zero and 120,000 ergs.

507. (4.10) Which of the following conditions or circumstances that characterize the motion of a falling body does Galileo *not* consider, in his investigation of falling bodies in Day III ("On Naturally Accelerated Motion")?

- **A.** The nature of the acceleration of a body falling through a buoyant and resistant medium.
- **B.** The distance traversed by a freely falling body.
- **C.** The speed of a freely falling body's motion.
- **D.** The length of time the fall has lasted.
- **E.** Each of the above factors is discussed by Galileo in his investigation.

508. (4.10) Which of the following headings does *not* characterize any significant part or aspect of Galileo's investigation of falling bodies in Day I (where he discusses Aristotle's two assumptions about the motions of bodies)?

- **A.** The Motion of Bodies Falling in a Vacuum.
- **B.** The Motion of Bodies in Various Real Media.
- **C.** Experimental Investigation of Falling Bodies.
- **D.** The Mathematical Relation of Distance to Time for a Freely Falling Body.
- **E.** Each of the above headings characterize a significant part of Galileo's investigation.

509. (4.10) In his discussion of Aristotle's assumption that bodies fall with speeds proportional to their weights, Salviati considers the motion of a body formed by uniting a large stone and a small stone, and concludes that this body should fall with a speed intermediate between the speeds of its parts, taken separately.

In drawing this conclusion, Salviati assumes that

- **A.** the tendency of a body to fall arises from the separate tendencies of its parts to fall.
- **B.** gravity is the sole cause of the weight of a body.
- **C.** the natural motion of a falling body is the motion it would possess in a vacuum.
- **D.** the natural motion of a falling body is uniformly accelerated.
- **E.** all bodies have the same natural speed of fall.

For each item select the best and most complete answer. Mark only *one* space per item.

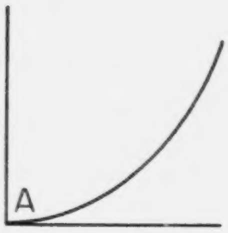
Items 510 - 515 are based upon the following set of data as measured on the tape from a free-fall apparatus.

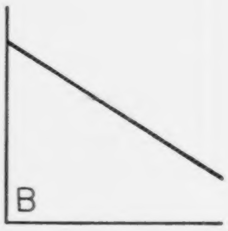
Time interval (1/40 sec.)	Distance in cm. traveled during time interval.
1	0.3
2	0.9
3	1.5
4	2.2
5	2.8
6	3.3
7	3.9
8	4.5

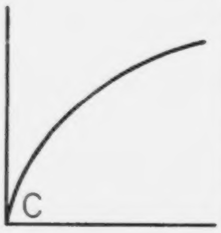
510. (4.20) The acceleration of the falling bob during the third time interval was

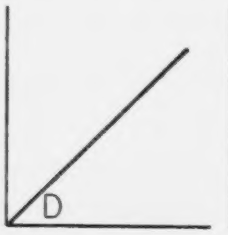
- **A.** equal to that during the second time interval.
- **B.** 3/2 times that during the second time interval.
- **C.** 9/4 times that during the second time interval.
- **D.** 5/3 times that during the second time interval.
- **E.** none of the above.

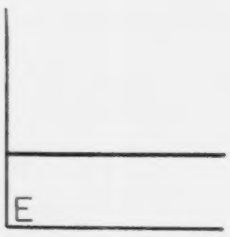
511. (2.20) If the time elapsed were plotted on the horizontal axis and the velocity on vertical axis, a graph of the data would take the general form of which of the following diagrams?











512. (2.20) If the time elapsed were plotted on the horizontal axis and the total distance traveled on the vertical axis, a graph of the data would take the general form of which of the above diagrams?

513. (2.20) If the time elapsed were plotted on the horizontal axis and the acceleration on the vertical axis, a graph of the data would take the general form of which of the above diagrams?

514. (3.00) The average velocity of the bob during the sixth time interval was approximately

A. 3.3 cm./sec. **B.** 440 cm./sec.
C. 312 cm./sec. **D.** 132 cm./sec.
E. 53 cm./sec.

515. (3.00) According to this data, the average acceleration due to gravity was

A. 980 cm./sec./sec. **B.** 960 cm./sec./sec.
C. 940 cm./sec./sec. **D.** 240 cm./sec./sec.
E. 1000 cm./sec./sec.

Items 516 and 517 refer to the following data: A baseball is thrown straight up from the top of a 1000-foot tower and because of a horizontal drift wind it falls to the ground on its return flight. Assume that the acceleration due to gravity is known (32ft./sec.^{2}).

516. (4.20) To find the total time of flight of the ball it is necessary to know

- **A.** both the velocity of the drift wind and the final velocity of the ball.
- **B.** the mass of the ball.
- **C.** the kinetic energy of the ball.
- **D.** only the velocity of the ball at the top of its flight.
- **E.** the velocity with which the ball is thrown upward.

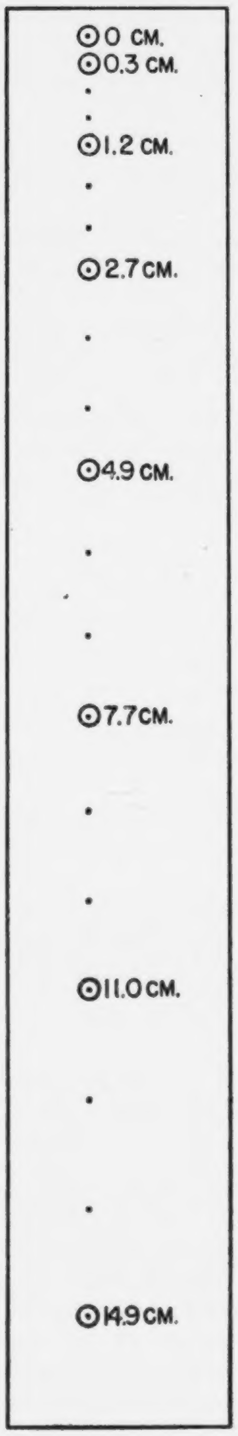
517. (4.20) The energy state of the ball is correctly given by the statement:

- **A.** At the height of the tower on the return flight, the ball possesses only potential energy.
- **B.** After the start of the flight, the kinetic energy is never zero until the ball reaches the ground.
- **C.** The maximum potential energy depends on the initial velocity of the ball.
- **D.** At the height of the tower on the return flight, the ball possesses only kinetic energy.
- **E.** At the instant the ball touches the ground, the kinetic energy is changed to potential energy.

The following is a set of data as measured on the tape from a free-fall apparatus such as that used in laboratory work. Items 518 - 522 are to be answered on the basis of this data. The time interval between encircled dots is 1/40 second.

518. (4.20) The acceleration of the weight during the third time interval was

- **A.** equal to that during the second time interval.
- **B.** 3/2 times that during the second time interval.
- **C.** 9/4 times that during the second time interval.
- **D.** 5/3 times that during the second time interval.
- **E.** none of the above.



519. (2.20) If the time elapsed were plotted on the horizontal axis and the velocity on the vertical axis, a graph of the data would take the general form of a diagram.

520. (4.20) In order to determine the momentum of the weight at the end of six time intervals, it would be necessary to know also

- **A.** all of the following.
- **B.** the coefficient of air friction.
- **C.** the mass of the weight.
- **D.** the distance of the zero point above base level.
- **E.** the potential energy of the weight.

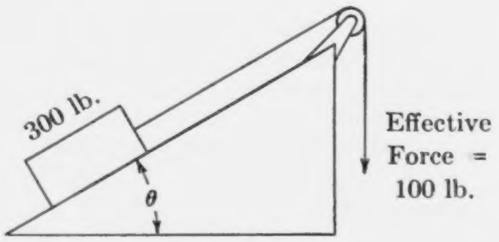
521. (3.00) The average velocity of the weight during the sixth time interval was approximately

- **A.** 3.3 cm./sec.
- **B.** 130 cm./sec.
- **C.** 440 cm./sec.
- **D.** 53 cm./sec.
- **E.** 310 cm./sec.

522. (3.00) According to this data, the average acceleration due to gravity was

- **A.** 980 cm./sec./sec.
- **B.** 960 cm./sec./sec.
- **C.** 776 cm./sec./sec.
- **D.** 1120 cm./sec./sec.
- **E.** 800 cm./sec./sec.

Items 523 and 524 refer to the following data and diagram: A man pulls a 300 lb. box at constant speed up an inclined plane by means of a rope, which is attached to the box and passes over a pulley at the top of the plane. The man exerts a force of 100 lbs. in addition to that necessary to overcome friction in a direction vertically downward.



Angle	Sin	Tan	Cot	Cos
18.5	.3173	.3346	2.9887	.9483
19.5	.3388	.3541	2.8239	.9426
70.5	.9426	2.8239	.3541	.3338
71.5	.9483	2.9887	.3346	.3173

523. (4.20) What is the approximate slope angle of the plane?

- **A.** 70.5°
- **B.** 71.5°
- **C.** 19.5°
- **D.** 18.5°
- **E.** None of these.

524. (4.20) The force exerted by the cord is

- **A.** 100 lb.
- **B.** 200 lb.
- **C.** 300 lb.
- **D.** 400 lb.
- **E.** Not determinable from this data.

525. (4.20) Two motorists travel from A to B, a distance of 121 miles. Both cars require 30 seconds to accelerate from 0 to 60 miles per hour. Car A maintained a constant speed of 60 mph except during acceleration and deacceleration at the start and at the destination. Car B stopped 6 minutes enroute. Allowing for the time to accelerate and deaccelerate for the additional stop, in order to reach the destination at the same time as Car A, what constant speed would Car B have to maintain? In solving this problem it is unnecessary to determine

- **A.** the distance each car travels during acceleration.
- **B.** the time required by Car A to make the trip.
- **C.** the distance from the starting point at which Car B stopped.
- **D.** the average velocity for car B.

526. (3.00) In the above problem the constant speed required for Car B is closest to

- **A.** 60 mph.
- **B.** 63 mph.
- **C.** 65 mph.
- **D.** 67 mph.
- **E.** 70 mph.

According to Newton, Galileo's investigation of falling bodies and projectiles made use of the first two Laws of Motion.

527. (4.20) Which of the following is a statement affirmed by Galileo, which may be taken to rest directly on Newton's first Law of Motion?

- **A.** The acceleration of a falling body is caused by the continual diminution of the upward force initially impressed on the body by the agent which projected it.
- **B.** The motion of a projectile has both a horizontal and vertical component.
- **C.** The horizontal component of a projectile motion is constant.
- **D.** Uniform motion is one in which equal distances are always traversed in equal times.
- **E.** Falling bodies are uniformly accelerated.

528. (4.20) To maintain that Galileo's investigation of naturally accelerated motion made use of Newton's second Law of Motion, it is necessary to suppose that Galileo accepted which of the following assertions?

- **A.** The weight of a falling body is a constant force.
- **B.** Pendulums of equal periods and equal lengths have weights proportional to their masses.
- **C.** Pendulums of equal length have equal periods.
- **D.** When a body falls to earth, the earth rises to meet the body.
- **E.** Gravity is a force whose absolute measure varies with position, but is independent of the body acted upon.

Note: The term "complete statement of a theory," in the following question, is to be taken to mean "statement of principle from which all the propositions of the theory can be deduced mathematically." Thus, in this sense, the axioms of geometry or Archimedes' postulate in "On Floating Bodies" are complete statements of the respective theories.

529. (4.20) The assertion contained in your answer to the preceding question

- **A.** can be taken as a complete statement of Galileo's theory of falling bodies and projectiles, given Newton's first two Laws.
- **B.** can be taken as a complete statement of Galileo's theory of falling bodies and projectiles, only if Newton's definitions of centripetal force and its absolute measure are assumed along with his first two Laws.
- **C.** can be taken as a complete statement of Galileo's theory of falling bodies and projectiles, only if in addition to the Definitions and Laws, certain propositions from Newton's first two Books are assumed.
- **D.** can be taken as a complete statement of Galileo's theory of falling bodies and projectiles, only if Newton's Law of Universal Gravitation is assumed.
- **E.** can be taken only as a partial statement of Galileo's theory, since it does not include some of Galileo's basic assumptions, e.g., his definition of naturally accelerated motion.

530. (4.20) Which of the following statements is true of *neither* of Galileo's investigations of falling bodies, in Day I and Day III?

- **A.** The result of the investigation is a theory which rests on one basic concept in terms of which all the propositions of the theory can be derived.
- **B.** The investigation is based upon an assumption which cannot be tested experimentally in any way, but is put forth as evident on logical grounds.
- **C.** In the course of the investigation, a change occurs in the conditions or variable circumstances which are regarded as significant in determining the motion of bodies.
- **D.** The conclusions of the investigation are not all equally precise; part of the subject is reduced to exact, numerical form, but some matters are dealt with only approximately.
- **E.** Results are attained by a combination of speculation, based on the notion that nature operates according to simple laws, and observation of the behavior of bodies.

531. Which of the following statements is true of *both* of
(4.20) Galileo's investigations of falling bodies, in Day I and Day III?

A. The result of the investigation is a theory which rests on one basic concept in terms of which all the propositions of the theory can be derived.

B. The investigation is based upon an assumption which cannot be tested experimentally in any way, but which is put forth as evident on logical grounds.

C. In the course of the investigation, a change occurs in the conditions or variable circumstances which are regarded as significant in determining the motions of bodies.

D. The conclusions of the investigation are not all equally precise; part of the subject is reduced to exact, numerical form, but some matters are dealt with only approximately.

E. Results are attained by a combination of speculation, based on the notion that nature operates according to simple laws, and observation of the behavior of bodies.

532. Which of the following is the principal factor marking
(4.20) a difference between Galileo's investigation of falling bodies in Day I and in Day III?

A. Experiment has an important role in only one of the two investigations.

B. The conditions or variable circumstances, whose consequences are under investigation, are different in the two investigations.

C. The assumption of ideal circumstances, which can be approximated but never realized fully, is made in one of the two investigations but not the other.

D. One of the investigations is concerned with establishing new principles concerning motion, the other with drawing consequences from principles already established.

E. One of the investigations is concerned really with a problem unrelated to the laws of falling bodies—namely, with the existence of a vacuum; the other is concerned with falling bodies for their own sake.

14. *Matter and Energy*

MATTER AND ENERGY

Items 1- 4 involve simple machines. For each item select from the key the type of simple machine which it illustrates.

KEY

A. Lever. **B.** Screw. **C.** Wedge.
D. Inclined plane. **E.** Wheel and axle.

1. (1.10) Adjustable piano stool.

2. (1.10) Ramp.

3. (1.10) Turning a screw driver.

4. (1.10) Nut cracker.

5. (1.10) Which one of these could be a specific gravity as used in a laboratory experiment?

A. 62.4 lbs./cu. ft. **B.** 2.7 gm./cm.^{3} **C.** 7.8
D. .09 gm./square cm. **E.** 76 cm. of mercury.

6. (1.10) A unit of power is the

A. dyne. **B.** erg. **C.** watt. **D.** foot-pound.
E. gram-centimeter.

7. (1.10) A unit of work is the

A. poundal. **B.** coulomb. **C.** erg. **D.** esu.
E. dyne.

8. (1.10) Energy may be defined as capacity for

A. exerting force. **B.** action. **C.** great power.
D. doing work. **E.** producing motion.

9. (1.10) An erg is equal to a

A. dyne-centimeter. **B.** dyne.
C. gram-centimeter. **D.** foot-pound. **E.** poundal.

10. (1.10) The energy possessed by a falling rubber ball at the middle of its flight is

A. largely heat energy.
B. partly kinetic and partly potential.
C. all potential. **D.** all kinetic.
E. impossible to predict because the ball is elastic.

Items 11 - 17 refer to various units of physical measurement in the metric system which have their counterpart in the English system of units. For each item select from the key the analogous unit or concept involved.

KEY

A. Poundal. **B.** Foot-pound per second.
C. Foot-pound. **D.** Cubic inch.
E. Pound per cubic foot.

11. (1.10) Joule.

12. (1.10) Liter.

13. (1.10) Watt.

14. (1.10) Dyne.

15. (1.10) Erg.

16. (1.10) Kilogram-meter.

17. (1.10) Gm./cm.^{3}

Items 18 - 21 refer to various units of physical measurement in the English system. For each item select from the key the analogous unit or concept involved.

KEY

A. Ergs. **B.** Dynes. **C.** Liters. **D.** Watts.
E. None of these.

18. (1.10) Foot-pound per second.

19. (1.10) Poundal.

20. (1.10) Horsepower.

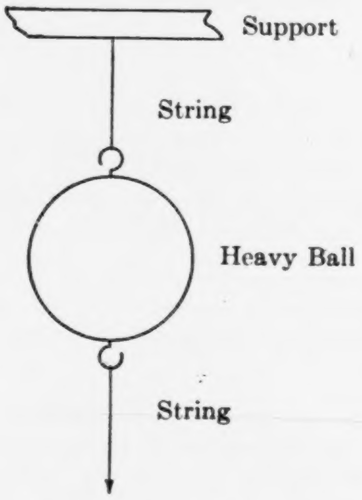
21. (1.10) Cubic inches.

22. (1.10) Measurement of which of the following quantities *cannot* be expressed in the units indicated?

A. Electricity—coulombs. **B.** Force—dynes.
C. Work—horsepower. **D.** Pressure—millibars.
E. Acceleration—feet per day per hour.

23. (1.10) Measurement of which of the following quantities *cannot* be expressed in the units indicated?

A. Force—dyne. **B.** Heat—British Thermal Unit.
C. Pressure—millibar.
D. Acceleration—feet per year per day.
E. Work—horsepower.



24. (1.10) A heavy ball is suspended by means of a string and another string is attached to the lower part of the ball. (Refer to diagram). A quick jerk on the lower string breaks it below the ball. A slow pull on the lower string breaks the string above the ball. The first result occurs because

A. the force is too small to move the ball.
B. to every action there is an equal and opposite reaction.
C. the inertia of the ball is not overcome.
D. friction holds the ball back.
E. the ball possesses too much energy.

Items 25 - 31 refer to units of measurement of fundamental quantities in physical science. For each item select from the key the term which relates to it.

KEY

A. Mass. **B.** Work. **C.** Force. **D.** Power.
E. Two of the above.

25. (1.10) Joule.

26. (1.10) Ft. lb./sec.

27. (1.10) Erg.

28. (1.10) K.W.H.

29. (1.10) Poundal.

30. (1.10) Watts.

31. Gram.
(1.10)

32. Inertia is the tendency of moving bodies
(1.10)

- **A.** to disintegrate or fall apart.
- **B.** to destroy energy.
- **C.** to retain their motion in a straight line.
- **D.** to give off energy or heat.
- **E.** to become magnetized.

33. Inertia is the tendency of bodies to
(1.10)

- **A.** move in the direction of an applied force.
- **B.** return to a state of equilibrium.
- **C.** maintain a state of equilibrium.
- **D.** transform mass into energy.
- **E.** attract all other bodies.

34. Mass differs from weight in that
(1.10)

- **A.** all objects have weight but some lack mass.
- **B.** weight is a force, mass is not.
- **C.** the mass of an object always exceeds its weight.
- **D.** the concept of mass can be expressed only in the metric system.
- **E.** none of the above; there is no difference.

35. The mass of an object
(1.10)

- **A.** has no dependence upon external forces.
- **B.** depends on the distance from the center of the earth.
- **C.** varies with the force of gravity.
- **D.** is equal to the density of the object.
- **E.** is the scientific name for the weight of the object.

36. When a person places a coin on a card and supports
(1.10) both on his finger, he may snap the card out from under the coil without disturbing it; this illustrates the principle of

A. centrifugal force. **B.** inertia.
C. accelerated motion. **D.** gravitation.
E. action-reaction.

37. As a stunt, a boy held a 10 lb. weight at arms length
(1.10) for 10 seconds. If his arm was 4 feet above the ground, the work (in ft. lb.) done while holding the weight was

A. 0. **B.** 4. **C.** 40. **D.** 100. **E.** 400.

38. Gasoline, a mixture of hydrocarbons, burns to carbon
(1.10) dioxide and water. In order to maintain a dirigible, or lighter-than-air airship, at a constant weight, the procedure used is to condense water vapor present in the exhaust gases from the engines and allow the CO_2 to escape. However, only about 70% of the water vapor need be condensed. Why?

- **A.** Water is denser than gasoline.
- **B.** Dirigibles filled with helium are heavier than those filled with hydrogen.
- **C.** The water contains oxygen from the atmosphere.
- **D.** Gasoline is about 70% carbon.
- **E.** The gasoline is not completely burned in the engines.

Items 39 - 46 are to be answered according to the following key.

KEY

- **A.** The item is true for metals.
- **B.** The item is true for non-metals.
- **C.** The item is true for both metals and non-metals.
- **D.** The item is true for neither metals nor non-metals.

39. Good conductors of heat and electricity.
(1.10)

40. Combine readily with elements of Group I of the periodic
(1.10) table.

41. Many are gases or low-melting solids.
(1.10)

42. Many have variable valence.
(1.10)

43. Their oxides in water form basic solutions.
(1.10)

44. Frequently good electron acceptors or oxidizing agents.
(1.10)

45. Chemically inert and form no compounds.
(1.10)

46. Combine chemically with oxygen to form oxides.
(1.10)

47. A ball is thrown up into the air. As it rises, there is an
(1.10) increase in its

A. acceleration. **B.** velocity. **C.** kinetic energy.
D. potential energy. **E.** momentum.

48. Great resistance to compression is a property of all
(1.10)

A. solids, liquids, and gases.
B. solids, liquids, but not gases. **C.** solids only.
D solids and gases, but not liquids. **E.** liquids only.

49. When the brakes are applied to a moving train, the
(1.10) energy of the train is transformed into

A. potential energy. **B.** heat.
C. electrical energy. **D.** kinetic energy.
E. chemical energy.

50. Which one of these has the smallest mass?
(1.10)

A. Neutron. **B.** Electron. **C.** Ion. **D.** Proton.
E. Atom.

51. If the amount of work done by a machine is known, the
(1.10) average power output can be found if

- **A.** the force acting is known.
- **B.** the efficiency can be determined.
- **C.** the time required to do the work is known.
- **D.** the mechanical advantage of the machine can be determined.
- **E.** the work done on the machine can be measured.

52. In general, which of the following engines operates
(1.10) with the greatest efficiency?

A. Reciprocating steam engine. **B.** Steam turbine.
C. Four-stroke cycle ignition-gasoline engine.
D. Two-stroke cycle ignition-gasoline engine.
E. Diesel engine.

53. A Diesel engine differs from the gasoline engine in
(1.10) that it

- **A.** uses more expensive fuel.
- **B.** makes a lighter weight engine per horse-power.
- **C.** needs no exhaust valves.
- **D.** compresses air rather than a fuel mixture.
- **E.** operates at a much lower temperature.

54. Nitrogen is least significantly associated with
(1.10)

A. the explosive industry.
B. dyes and the dyeing industry. **C.** soil fertility.
D. poison war gases. **E.** proteins.

55. Which of the following properties does not contribute
(1.10) to the usefulness of metals?

A. Malleability. **B.** Ductility.
C. High tensile strength.
D. High dielectric constants.
E. Resistance to corrosion.

56. Sodium is different from common metals in being
(1.10)

A. lighter than water. **B.** opaque. **C.** malleable.
D. of metallic lustre. **E.** a nonconductor of heat.

57. A simple machine can be used to
(1.10)

A. store up energy.
B. obtain a large amount of power from the operation of a small force.
C. obtain energy. **D.** transfer a force.
E. increase energy put into it.

58. Which one of these is inert?
(1.10)

A. Argon. **B.** Nitrogen. **C.** Hydrogen.
D. Oxygen. **E.** Two of the above.

59. Which one of the following is an inert gas?
(1.10)

A. Ammonia. **B.** Carbon monoxide.
C. Hydrogen. **D.** Carbon dioxide. **E.** Helium.

60. A gas commonly used in electric light bulbs to retard
(1.10) vaporization of the filament is

A. neon. **B.** helium. **C.** oxygen. **D.** argon.
E. krypton.

61. Which one of these *cannot* form molecules through com-
(1.10) bination of atoms?

A. Oxygen. **B.** Nitrogen. **C.** Hydrogen.
D. Helium. **E** Two of the above.

62. Iodine may be characterized as
(1.10)

A. a halogen.
B. an element behaving chemically similarly to carbon.
C. an inert gas. **D.** a radioactive element.
E. an active metal.

For 63 - 67 select from the key the most appropriate response.

KEY

A. Hydrogen. **B.** Oxygen. **C.** Nitrogen.
D. Chlorine. **E.** None of these.

63. An element present in proteins which distinguishes pro-
(1.10) teins from carbohydrates.

64. An element present in the most important fuels.
(1.10)

65. An element which is always inert.
(1.10)

66. An element which is a constituent of quartz.
(1.10)

67. An element which, from its presence in other substances,
(1.10) is generally a ready source of protons.

68. Which one of the following pure compounds contains
(1.10) water vapor?

A. Dry ice. **B.** Hydrogen peroxide. **C.** Ammonia.
D. Hydrogen chloride. **E.** None of these.

Item 69 deleted.

70. A hydrate is
(1.10)

A. a moist compound. **B.** a liquefied element.
C. usually an organic compound.
D. reduced in molecular weight if heated sufficiently.
E. the product produced when an hydroxide and an acid react.

71. One cubic foot of water weighs
(1.10)

A. 33⅓ lbs. **B.** 64.2 lbs. **C.** 62.4 lbs. **D.** 8 lbs.

72. Comparing equal volumes of mercury and water, one
(2.10) cubic foot of mercury weighs

A. 848.64 lbs. **B.** 968 lbs. **C.** 13.6 lbs.
D. 462 lbs. **E.** 1204 lbs.

73. 50 cubic centimeters of water weighs
(1.10)

A. 62.4 grams. **B.** 50 grams. **C.** 25 grams.
D. 88 grams.

74. If coal has a specific gravity of 1.3, a cubic foot of
(2.10) coal weighs

A. 62.4 lbs. **B.** 72 lbs. **C.** 81.12 lbs.
D. 2184.24 lbs.

75. If ice has a density of .9 then a cubic foot of ice weighs
(2.10)

A. 56.16 lbs. **B.** 60.2 lbs. **C.** 71.3 lbs.
D. 43.08 lbs.

Items 76 - 82. After each item number on the answer sheet, blacken space

A. if the item is true of sulfides.
B. if the item is true of oxides.
C. if the item is true of elements in the elementary form.
D. if the item is true of silicates.
E. if the item is true of chlorides.

76. Commercial iron ore is an example.
(1.10)

77. Gold as it usually occurs in nature.
(1.10)

78. The most abundant of the above.
(1.10)

79. Deposited from solution through evaporation of sea
(1.10) water.

80. Certain ores of mercury, zinc, lead, copper, and anti-
(1.10) mony are examples.

81. Aluminum ore is an example.
(1.10)

82. Elements above hydrogen in the activity series do not
(1.10) occur in commercial amounts in this form in nature.

Items 83 - 92. Underscore the correct answer.

83. Potential energy is
(1.10)

A. energy of position. **B.** energy of motion.
C. heat energy.

84. Kinetic energy is
(1.10)

A. energy of position. **B.** weight x height.
C. force x distance. **D.** $\frac{1}{2}MV^2$. **E.** $\frac{MV^2}{R}$

85. Energy is
(1.10)

A. work. **B.** a force. **C.** power.
D. ability to do work.

86. Work really is
(1.10)

A. power. **B.** a weight times a height.
C. force times distance.
D. force times distance divided by time.

87. Efficiency is
(1.10)

A. input divided by output.
B. amount of work gotten out of a machine.
C. the amount of work put into a machine.
D. output divided by input.

88. From a simple machine we get
(1.30)

A. more work out of it than we put into it.
B. less work out than is put into it.
C. input work equal to the output work.
D. all the output in the form of heat.

89. True mechanical advantage is
(1.10)

A. weight divided by force.
B. distance the weight moves divided by the distance that the force moves.
C. output divided by input. **D.** always zero.

90. A moment of force is the
(1.10)

A. perpendicular distance from a line that passes through the force to the point of rotation times the force.
B. small unit of time multiplied by the force.
C. point outside the plane of forces.
D. sum of the forces.

91. Power may be measured in
(1.10)

A. ergs. **B.** dynes. **C.** foot-pounds.
D. horse power. **E.** B.T.U.

92. Concurrent forces are
(1.10)

A. forces that are parallel to each other
B. forces that are through a common point.
C. forces that occur at regular intervals.
D. forces that are in equilibrium.

Items 93 - 117 have statements related to *potential energy, kinetic energy, work, work machines* and *power*. In the bracket at the left of each item, mark

(A) For Potential energy. (B) For Kinetic energy.
(C) For Work. (D) For Work Machines.
(E) For Power.

93. ( ) A ten pound weight is suspended at a height of 100 feet.
(1.10)
(1.23)

94. ( ) A force of 50 pounds acts through a distance of 10 feet.
(1.10)
(1.23)

95. ( ) A wound clock spring.
(1.10)
(1.23)

96. ( ) 500 pounds of force acting through a distance of 180 ft. for 3 minutes.
(1.10)
(1.23)

97. ( ) A claw hammer.
(1.10)
(1.23)

98. ( ) A baseball that has a speed of 60 feet per second.
(1.10)
(1.23)

99. ( ) A screw jack.
(1.10)
(1.23)

100. ( ) A loaded shot gun shell.
(1.10)
(1.23)

101. ( ) A dyne centimeter.
(1.10)
(1.23)

102. ( ) An erg.
(1.10)
(1.23)

103. ( ) 550 lbs. per second.
(1.10)
(1.23)

104. ( ) A pound of dynamite.
(1.10)
(1.23)

105. ( ) A bee in flight.
(1.10)
(1.23)

106. ( ) A picture on the wall.
(1.10)
(1.23)

107. ( ) A plank with one end on a loading deck, the other on the ground.
(1.10)
(1.23)

108. ( ) A pound of coal.
(1.10)
(1.23)

109. ( ) A freely falling body.
(1.10)
(1.23)

110. ( ) A crow bar.
(1.10)
(1.23)

111. ( ) A block and tackle.
(1.10)
(1.23)

112. ( ) 746 watt seconds.
(1.10)
(1.23)

113. ( ) 778 foot pounds.
(1.10)
(1.23)

114. ( ) A pair of tinner's snips.
(1.10)
(1.23)

115. (1.10) (1.23) ( ) A five ton weight lifted to a height of 100 feet in 5 seconds.

116. (1.10) (1.23) ( ) A ten gram bullet fired with a velocity of 1200 feet per second.

117. (1.10) (1.23) ( ) A spring under compression.

118. (1.10) In which of the following situations is work being done?

A. A body sliding along a frictionless, horizontal plane.
B. A man holding a suitcase off the ground while waiting for the bus.
C. The moon in its orbit traveling around the earth.
D. Lifting a half-dollar through a height of one meter.
E. Two teams of equal strength pulling on opposite ends of a rope.

119. (1.10) A golf ball is hit and falls on a "green" on a hilltop above the rest of the golf course. The potential energy of the ball is greatest when it

A. comes to rest on the green.
B. is hit by the golf club.
C. strikes the green and then rolls to its final resting place.
D. reaches its highest point in flight.
E. rolls off the green and down the other side of the hill.

After each exercise number on the answer sheet, blacken the one lettered space which designates the correct answer.

120. (1.10) Energy may be defined as

A. a continually operating force.
B. the product of the mass and the velocity.
C. the capacity to do work.
D. the amount of inertia of a body.
E. the distance of an object above the earth.

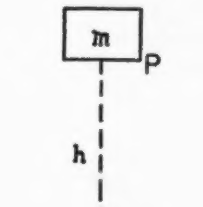
121. (1.10) A ball is dropped and hits the floor at X and rebounds upward to a point Y. While it is moving from X to Y its

A. kinetic energy is constant.
B. the kinetic energy is changing to potential energy.
C. kinetic energy is increasing.
D. potential energy is decreasing.

122. (1.10) The mechanical efficiency of a machine is the

A. work output divided by the work input.
B. power the machine will develop.
C. resistance divided by the effort.
D. distance the effort travels divided by the distance the resistance travels.
E. work done by the machine in one second.

123. (1.30) The mass, m, at point P falls a distance "h" to Q. Which of the following are equal? (Be sure to read all of the answers.)



A. The kinetic energy at Q and the potential energy at P.
B. mgh and ½ mv^2.
C. The kinetic energy at Q and the work required to lift m from Q to P.
D. The potential energy at P and the work required to lift m from Q to P.
E. All of the above are equal.

124. (1.30) When an object falls from a position 300 feet high, its energy

A. increases during its fall.
B. decreases during its fall.
C. remains constant during its fall.
D. is zero at the start of the fall.
E. is a maximum at the end of the fall.

125. (1.10) The object referred to in the preceding exercise has its maximum potential energy

A. at the start of the fall.
B. one-fourth the way down.
C. one-half the way down.
D. three-fourths the way down.
E. at the instant of impact.

126. (1.10) The object has its maximum kinetic energy

A. at the start of the fall.
B. one-fourth the way down.
C. one-half the way down.
D. three-fourths the way down.
E. at the instant of impact.

127. (1.30) The kinetic and potential energies of the object are equal

A. at the start of the fall.
B. one-fourth the way down.
C. one-half the way down.
D. three-fourths the way down.
E. at the instant of impact.

128. (3.00) Two hammers are used to drive stakes into the ground, the one hammer weighs 30 pounds and drives the stake 20 inches deep in only 3 minutes. The lighter hammer weighs 10 pounds and must be used for 12 minutes to drive another stake the same depth. The work done by the hammers was (assume both stakes have equal resistance to the hammers.)

A. zero. **B.** twice as much for the larger hammer.
C. one-fourth as much for the small hammer.
D. equal.
E. one-third as much for the larger hammer.

129. (1.30) The amount of work required in stopping a moving object is equal to the

A. velocity of the object.
B. kinetic energy of the object.
C. mass of the object times its acceleration.
D. potential energy of the object at rest.
E. square of the velocity of the object.

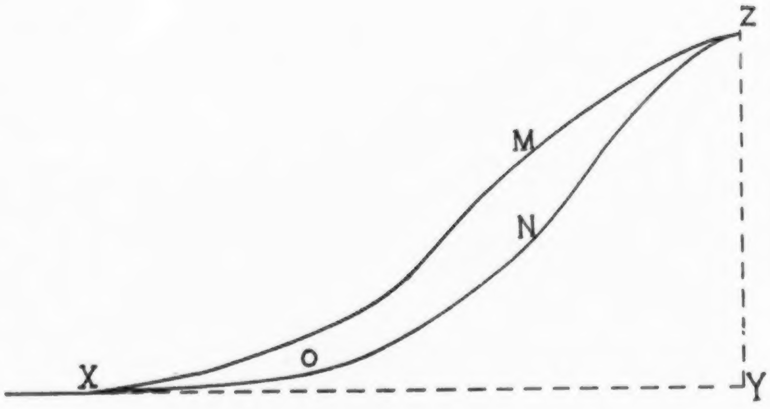
130. (1.10) In raising an object to a given height by means of an inclined plane, as compared with raising the object vertically to the same height, there is a reduction in the

A. total amount of work required.
B. amount of potential energy acquired by the object.
C. speed with which the purpose can be accomplished.
D. force required. **E.** amount of energy required.

Blacken space

- **A.** if the item at the left is of greater magnitude than that at the right
- **B.** if the item at the right is of greater magnitude than that at the left.
- **C.** if they are approximately of the same magnitude.

131. (1.10)	The work represented by a dyne centimeter.	....	The work represented by an erg.
132. (1.10)	Work required to raise a 10 lb. object through a vertical distance of 30 feet.	....	Potential energy of the 10 lb. object at a vertical height of 300 feet.
133. (1.10)	Potential energy of an object at a height of 30 feet.	....	Kinetic energy of the same object the instant before it strikes the earth.
134. (1.24)	The mechanical advantage of an inclined plane 40 feet long with a vertical height of 2 feet.	....	The mechanical advantage of an inclined plane 60 feet long with a vertical height of 2 feet.
135. (1.10)	Force necessary to move a 3000 lb. car up an inclined plane 40 feet long with a vertical height of 2 feet.	....	Force necessary to move the same car up an inclined plane 60 feet long with a vertical height of 2 feet.
136. (1.10)	Useful work performed in pulling a coaster wagon 30 feet.	....	Useful work performed in pushing on a stalled car which you do not move.
137. (1.30)	The amount of energy required to move an object a given distance with a crowbar, neglecting friction.	....	The work accomplished in moving the object the same distance with the crowbar, neglecting friction.
138. (1.10)	The work represented by one joule.	....	The work represented by one erg.
139. (1.10)	The effort force required to move an object with a crowbar.	....	The resistance force of the object being moved by the crowbar.
140. (1.10)	The distance traveled by the effort force in moving the object with the crowbar.	....	The distance traveled by the resisting force in being moved by the crowbar.
141. (1.10)	Energy required in climbing a steep hill.	....	Energy required in climbing the same hill along a longer and less steep path.
142. (1.10)	Force required to raise a piano directly up to a window 6 feet above the ground.	....	Force required to raise the piano to the window along an inclined plane 12 feet long.
143. (1.10)	Work done in raising the piano directly up, neglecting friction.	....	Work done in raising the piano along the plane, neglecting friction.



The diagram above represents two hills of different slopes. Neglect friction and air resistance and assume that potential energy is measured from the level of the horizontal line XY. The hill on which point M is located is referred to as the "upper" hill and the hill on which points N and O are located is referred to as the "lower" hill. Assume for the items in which a sled slides down either of these hills that it starts from rest at point Z. Potential energy is equal to mgh and kinetic energy is equal to $\frac{1}{2}mv^2$. Force is equal to ma, work is equal to force times distance, and power is equal to work done per unit of time. Mechanical advantage of a frictionless inclined plane is equal to the length of the plane divided by the vertical height.

After the answer sheet number corresponding to that of each of the following paired items, blacken space

- **A.** if the item at the left is greater than the item at the right.
- **B.** if the item at the right is greater than the item at the left.
- **C.** if the two items are of the same magnitude.

144. (1.10)	Potential energy acquired by a person climbing the upper hill from X to Z.	....	Potential energy acquired by the same person climbing the lower hill from X to Z.
145. (1.10)	Potential energy of a person climbing the upper hill from X to point M.	....	Potential energy of the same person climbing the lower hill from X to N.
146. (1.10)	Loss of potential energy of the sled in coasting from Z to X along the upper hill.	....	Loss of potential energy of the sled in coasting from Z to X along the lower hill.
147. (1.10)	Loss of potential energy of a sled in sliding from Z to X along the upper hill.	....	Gain in kinetic energy of the same sled in falling freely from Z to Y.
148. (1.10)	Kinetic energy of a person and sled when coasting past point M on the upper hill.	....	Kinetic energy of the same person and sled when coasting past point N on the lower hill.
149. (1.10)	Kinetic energy of the sled when it has coasted down the upper hill and is passing point X.	....	Kinetic energy of the sled when it has coasted down the lower hill and is passing point X.
150. (1.10)	Velocity of a person sliding down the upper hill when passing point X.	....	Velocity of the same person sliding down the lower hill when passing point X.

151. (1.10)	Velocity of a person sliding down the upper hill on a sled when passing point M.	....	Velocity of the same person when sliding down the lower hill when passing point N.
152. (1.10)	Velocity of a sled while sliding down the lower hill when it passes point O.	....	Velocity of the same sled while sliding down the lower hill when it passes point N.
153. (1.10)	Force required to raise a sled from Y to Z.	....	Force required to pull the same sled along either hill from X to Z.
154. (1.10)	Work done on a sled in pulling it along the upper hill from X to Z.	....	Work done on the same sled in raising it from Y to Z.
155. (1.10)	Work done on a sled in pulling it along the upper hill from X to Z.	....	Work done on the same sled in pulling it along the lower hill from X to Z.
156. (1.10)	Force required to stop a sled at point X after the sled has coasted down the upper hill.	....	Force required to stop the same sled at point X after the sled has coasted down the lower hill.
157. (1.10)	The power required to pull a sled 10 feet up the lower hill near point O and in a given amount of time.	....	The power required to pull the same sled 10 feet up the lower hill near point N and in the same amount of time.
158. (1.10)	The power required to pull a sled from X to Z along the upper hill in three minutes.	....	The power required to pull a sled from X to Z along the lower hill in three minutes.
159. (1.10)	The power required to pull a sled along the upper hill from X to Z in three minutes.	....	The power required to pull a sled along the upper hill from X to Z in five minutes.

160. Tungsten is used as a filament in electric light bulbs because of its
(1.10)

A. low density. **B.** high electrical resistance.
C. high melting point.
D. high coefficient of expansion.

161. A simple machine is sometimes used to
(1.10)

A. obtain a large amount of power from the operation of a small force.
B. substitute a small force for a large one.
C. store up energy.
D. increase the energy put into the machine.
E. do away with friction.

162. Mercury is used in barometers because of its
(1.10)

A. good electrical conductivity. **B.** high density.
C. attractive luster. **D.** high thermal conductivity.

163. The mass of a substance is
(1.10)

A. described as a property of a substance by virtue of which it possesses inertia.
B. the density of its particles.
C. dependent upon the gravitational pull of the earth or some other body.
D. a force which accelerates a body.
E. its weight in any set of weight units.

164. Which one of these is true concerning density?
(1.10)

A. The density of water in lb./per ft.^{3} has the same value numerically when measured in gm./per cm.^{3}.
B. Density and specific gravity have the same meaning.
C. In metric units of measurement, density and specific gravity have the same numerical value.
D. The density of water is greater than that of any other liquid.
E. Density is a ratio number.

165. An instrument which is used to measure liquid density is a
(1.10)

A. hygrometer. **B.** hydrometer. **C.** pyrometer.
D. barometer. **E.** none of these.

166. A device for the direct measurement of the specific gravity of a liquid is the
(1.10)

A. burrette. **B.** optical pyrometer. **C.** barometer.
D. hydrometer. **E.** hygrometer.

Items 167 - 170 involve properties of certain substances. Select from the key the substance which has the property indicated by each item.

KEY

A. Carbon dioxide. **B.** Water. **C.** Oil.
D. Mercury. **E.** Alcohol.

167. A liquid which is miscible with water.
(1.10)

168. The listed substance having the greatest density.
(1.10)

169. The substance having the lowest boiling point.
(1.10)

170. A substance capable of floating an alloy whose specific gravity is 10.
(1.10)

171. Time is a factor in all these quantities *except*
(1.10)

A. the product $n\lambda$. **B.** amperes. **C.** acceleration.
D. the heat developed in a resistance. **E.** inertia.

172. Time is involved in all of these *except*
(1.10)

A. watts. **B.** horsepower. **C.** rate of working.
D. calories. **E.** power.

173. Under normal conditions air and oxygen differ in
(1.10)

A. state. **B.** color. **C.** odor. **D.** density.
E. taste.

174. Under normal atmospheric pressure, dry-ice, a well-known chemical compound, may exist as a
(1.10)

A. liquid only. **B.** solid only. **C.** solid or liquid.
D. solid or gas. **E.** solid, liquid or gas.

175. A bomber in level flight at an altitude of 15,000 feet and with a speed of 300 miles per hour drops a bomb. Which one of the following is true?
(1.10)

A. At the half-way mark after release, the bomb has both kinetic and potential energy.
B. The kinetic energy before the bomb is released is zero.

C. Just before impact, the bomb has its greatest potential energy.
D. The chemical energy of the bomb furnishes it with kinetic energy in flight.
E. All of the energy of the bomb is potential before it is dropped.

176. *No* kinetic energy is possessed by
(1.10)

A. a shooting star.
B. a propeller on a plane during flight.
C. a pendulum at the middle of its swing.
D. an elevator standing at the fifth floor.
E. a cyclone.

177. Inertia is the tendency of bodies to
(1.10)

A. destroy energy through resistance.
B. stretch beyond the elastic limit.
C. maintain their existing state of rest or motion.
D. become magnetized rather than to be attracted or repelled.
E. disintegrate or fall apart.

178. A man held one end of a 10 foot see-saw while a child weighing 40 lb. sat on the other end 2 feet off the ground.
(1.10)

The work done by the man is

A. 0 ft. lbs. **B.** 40 ft. lbs. **C.** 80 ft. lbs.
D. 400 ft. lbs. **E.** none of these.

179. The energy possessed by a bouncing rubber ball at the middle of its flight is
(1.10)

A. all kinetic. **B.** largely heat energy.
C. all potential. **D.** part kinetic and part potential.
E. impossible to predict because the ball is elastic.

180. Work, as used in science, means
(1.10)

A. mass times the velocity.
B. the force times the time of application of that force.
C. that a machine can give a mechanical advantage.
D. that a force has displaced a body.
E. the power consumed.

181. Four of these are related in some way. Which one is not?
(1.10)

A. Hydrometer. **B.** Archimedes. **C.** Barometer.
D. Density. **E.** Specific gravity.

182. Inertia is a term associated with
(1.10)

A. force. **B.** weight. **C.** mass. **D.** work.
E. two of the above.

183. A machine is a device in which
(1.10)

A. we can obtain more energy than we expend.
B. the greater the mechanical advantage the greater is the efficiency.
C. energy may be transferred.
D. the practical mechanical advantage can never be greater than 100.
E. the practical mechanical advantage is always greater than the ideal mechanical advantage.

184. The hydraulic press
(1.10)

A. does more work than is done upon it.
B. must make use of water as the liquid.
C. gives better results when the atmospheric pressure is high.
D. shows an application of Charles' law.
E. shows an application of Pascal's principle.

185. If a body has the ability to do work, the measure of the work it can do is its
(1.10)

A. force. **B.** power. **C.** energy. **D.** motion.
E. speed.

186. Nitrogen
(1.10)

A. forms one of the most stable diatomic molecules known.
B. is used in the space above the mercury in thermometers because it liquefies at a very low temperature.
C. forms nitrites when heated with nearly all metals.
D. forms ammonia when heated to an extremely high temperature in the presence of platinum.
E. is used in electric light bulbs to eliminate oxidation of the tungsten filament.

187. In the Lindé liquid air machine the cooling effect is due to
(1.10)

A. the boiling of a liquid.
B. the work done by the air when it expands.
C. the energy required to overcome the cohesion between molecules.
D. the calcium chloride solution.
E. the energy required to compress the air.

188. Of the two forms of phosphorus
(1.10)

A. both glow brightly in the dark.
B. red phosphorus is always formed when the vapor condenses.
C. white phosphorus is very inflammable but red phosphorus will never burn.
D. white phosphorus is very poisonous but red phosphorus is much less poisonous.
E. only the white variety is useful in matches.

189. Activated charcoal
(1.10)

A. is used in gas masks because it absorbs gases with high critical temperatures.
B. catalyzes the oxidation of poison gas by air.
C. is used to improve the wearing qualities of tires.
D. is used to reduce iron ore to iron.
E. is used in gunpowder.

190. Methane
(1.10)

A. is the principal constituent of natural gas.
B. is formed when hydrogen is discharged at a graphite cathode.
C. requires three times its own volume of oxygen for complete combustion.
D. is the simplest branched-chain hydrocarbon.
E. mixed with steam constitutes water gas.

191. At present, the most important demand for potassium salts is for use
(1.10)

A. in gunpowder. **B.** in matches.
C. in the manufacture of cement.
D. as laboratory reagents. **E.** as fertilizer.

192. (1.10) The following are the common names of the materials indicated:

- **A.** $Ca(OH)_2$ is quick lime.
- **B.** a mixture of $CaCO_3$ and CaO is mortar.
- **C.** $CaCO_3$ is slaked lime.
- **D.** $KHCO_3$ is baking powder.
- **E.** a solution of $Ca(OH)_2$ is lime water.

193. (1.10) Aluminum

- **A.** in a finely powdered state is a powerful oxidizing agent.
- **B.** dissolves in mineral acids but not in alkaline solution.
- **C.** was one of the first metals to be produced on a large scale.
- **D.** is a better electrical conductor than copper, weight for weight.
- **E.** is used for the casing of incendiary bombs.

194. (1.10) An alum

- **A.** has the general formula $M_2(SO_4)_3$.
- **B.** does not necessarily contain aluminum.
- **C.** is an anhydrous salt.
- **D.** gives off CO_2 when heated with cream of tartar.
- **E.** one variety, commonly called alundum, is commonly used as an abrasive.

195. (1.10) Concerning the different varieties of iron,

- **A.** wrought iron contains the greatest percentage of carbon.
- **B.** high carbon steel is similar in composition to wrought iron.
- **C.** cast iron cannot be tempered.
- **D.** in the United States most of the steel is made by the Bessemer process.
- **E.** gray cast iron contains no carbon.

196. (1.10) A machine is a device which

A. makes energy. **B.** may transfer energy.
C. gives something for nothing.
D. delivers more work than it receives.
E. always substitutes large forces for smaller ones.

197. (1.10) Suitable units for expressing energy are

A. watts. **B.** foot pounds. **C.** meters.
D. pounds. **E.** hours.

198. (1.10) Which one of the following is *not* correct?

- **A.** There are 1000 milligrams in a gram.
- **B.** There are 1000 milliliters in a liter.
- **C.** There are 100 centimeters in a meter.
- **D.** There are 100 millimeters in a centimeter.
- **E.** There are 1000 grams in a kilogram.

199. (1.10) Three, and only three, of the following are used in the production of alloy steels.

a. bauxite. b. mercury. c. chromium.
d. tungsten. e. nickel.

The three which are used in alloy steels are

A. a, c, and e. **B.** a, b, and c. **C.** b, c, and e.
D. c, d, and e. **E.** b, c, and d.

200. (1.10) Select the correct statement or statements among those below concerning internal combustion engines.

- a. In a diesel engine, the fuel is mixed with air in the carburetor before entering the cylinder.
- b. A diesel engine does not use a spark plug for igniting the fuel in the cylinder.
- c. The four-stroke cycle may be used in either the diesel engine or the gasoline engine.

The correct selection of statements includes only

A. a. **B.** b. **C.** c. **D.** b and c. **E.** a and b.

201. (1.12) A tight screw can be loosened more easily with a thick-handled screwdriver than with a thin-handled one. This is true because the large screwdriver

A. is stronger. **B.** is more efficient.
C. reduces the friction to a greater extent.
D. yields a greater moment of force.
E. has greater mass.

202. (1.22) If the amount of work done by a machine is known, the average power output can be found if

- **A.** the force acting is known.
- **B.** the efficiency can be determined.
- **C.** the time required to do the work is known.
- **D.** the mechanical advantage of the machine can be determined.
- **E.** the work done on the machine can be measured.

In each of items 203 - 208 blacken the answer space which corresponds to the letter of the *one* type of energy transformation (see Key) which is characteristic in the operation of the device or instrument, or which is characteristic of the particular phenomenon stated in the item.

KEY

- **A.** electrical energy into mechanical energy.
- **B.** electrical energy into chemical energy.
- **C.** radiant energy into chemical energy.
- **D.** radiant energy into electrical energy.
- **E.** electrical energy into radiant energy.

203. (1.20) The production of an image on a photographic plate.

204. (1.20) Photoelectric effect. **205.** (1.20) Electric motor.

206. (1.20) Synthesis of starch in the green leaf of a plant.

207. (1.20) Electric lamp. **208.** (1.20) Charging of storage battery.

Items 209 - 212 refer to types of energy changes. Select from the key the type of change involved in the item.

KEY

- **A.** The change is from radiant energy to chemical energy.
- **B.** The change is from chemical energy to heat energy alone.
- **C.** The change is from chemical energy to heat energy and mechanical energy.
- **D.** The change is from heat energy to mechanical energy.
- **E.** The change is from mechanical energy to heat energy.

209. The operation of an automobile engine.
(1.20)

210. The growth of vegetation which later changed to coal.
(1.20)

211. The transformation of water to steam, and the expansion of the steam in the cylinder of a steam engine.
(1.20)

212. The burning of coal.
(1.20)

213. What change increases the mechanical advantage of an inclined plane?
(1.22a)

- **A.** An increase in its height and a decrease in its length.
- **B.** A proportional increase in both its length and its height.
- **C.** A proportional decrease in both its length and its height.
- **D.** An increase in its length and a decrease in its height.

Items 214 - 219 involve simple machines. For each item select from the key the type of simple machine which it illustrates.

KEY

A. Lever. **B.** Inclined plane. **C.** Pulley.
D. Wheel and axle. **E.** None of these.

214. Ramp.
(1.23)

215. Block and tackle.
(1.23)

216. Human arm.
(1.23)

217. Rotary egg beater.
(1.23)

218. Tweezers.
(1.23)

219. Coal chute.
(1.23)

After each item number on the answer sheet, blacken space

- **A.** if the process represents a change of potential energy to kinetic energy.
- **B.** if the process represents a change of kinetic energy to potential energy.
- **C.** if the process represents a change of heat energy to kinetic energy.
- **D.** if the process represents a change of potential energy to heat energy.
- **E.** if the process represents a change of kinetic energy to heat energy.

220. A fireman sliding down a pole.
(1.23)

221. Heating a gas in a balloon.
(1.23)

222. A moving object at the moment it strikes the ground.
(1.23)

223. Applying the brakes on a car to bring it to a stop.
(1.23)

224. A rocket traveling away from the earth after it has received its initial thrust.
(1.23)

225. Evaporation of water.
(1.23)

226. Melting ice.
(1.23)

227. A comet moving toward the sun.
(1.23)

228. An outfielder on a baseball team catching a fly ball.
(1.23)

The work of our civilization is accomplished by energy in a variety of forms such as

A. Potential. **B.** Kinetic. **C.** Chemical.
D. Electrical. **E.** Radiant.

After each item number on the answer sheet blacken the space representing the proper form of energy listed above.

		Discr.	Difficulty
229. (1.23)	A stick of dynamite explodes.	.26	69%
230. (1.23)	An arrow is released from a bent bow.	.26	75
231. (1.23)	The storage battery in an automobile.	.22	49
232. (1.23)	An automobile coasting down a hill.	.22	74
233. (1.23)	When water is retained by a large dam.	.46	81
234. (1.23)	When a spring is stretched.	.30	63
235. (1.23)	The burning of coal.	.12	67
236. (1.23)	The waves from a radio transmitter.	.15	39
237. (1.23)	A windmill in operation.	.37	86
238. (1.23)	The product of a dynamo.	.30	86
239. (1.23)	The operation of a vacuum cleaner.	.10	74

240. A steam turbine is usually more efficient than a reciprocating type of steam engine *chiefly* because in the steam turbine
(1.24)

- **A.** greater expansion of steam occurs.
- **B.** there are fewer different moving parts.
- **C.** no condenser is needed.
- **D.** all motion is rotary rather than partly back and forth.
- **E.** very high operating speeds are possible.

241. The fact that a swinging pendulum eventually comes to rest is not a violation of the Law of Conservation of Energy because energy may be
(1.24)

- **A.** created but not destroyed.
- **B.** destroyed but not created.
- **C.** created and destroyed but not transferred from one form into another.
- **D.** changed from one form to another but neither created nor destroyed.

242. The chemical inertness of hydrogen at room temperature
(1.24)

- **A.** is due to the lightness of the molecule.
- **B.** is due to its reluctance to form covalent, as distinct from electrovalent, compounds.
- **C.** is due to its extremely low position in the activity list of the metals.
- **D.** is utilized in the production of high temperatures.
- **E.** is due to the stability of the molecule.

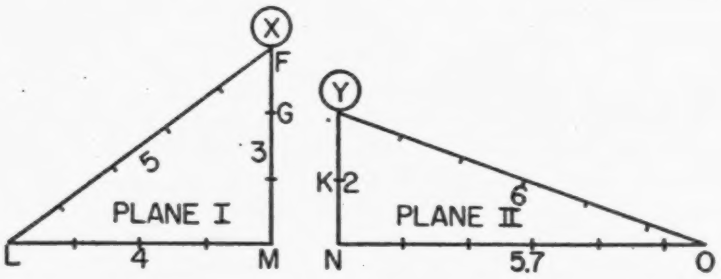
243. Which of the following statements states correctly a
(1.24) characteristic distinction between metals and nonmetals?

- **A.** Metals are high in melting point and density whereas nonmetals are not.
- **B.** Nonmetals are either gases or solids whereas all metals are liquids above their melting points.
- **C.** Nonmetals usually exert a stronger attraction for electrons than do metals.
- **D.** Metals are fewer in number than nonmetals.
- **E.** Nonmetals form covalent bonds whereas metals form ionic bonds.

For items 244 - 248 consider each of the paired phrases from the standpoint of quantity, and select from the key the appropriate response.

KEY

- **A.** The quantity at the left is greater than that at the right.
- **B.** The quantity at the left is smaller than that at the right.
- **C.** The two quantities are of essentially the same magnitude.
- **D.** The information given is insufficient for a comparison to be made.



Two spheres, X and Y, of equal masses and radii are placed on two inclined planes, as shown in the diagram. Neglect air resistance and other friction, and assume that potential energy is measured from the level of points L, M, N, and O.

244. (1.30)	Kinetic energy of X on rolling to L.	Kinetic energy of Y on rolling to O.
245. (1.30)	Work done on X in raising it from M to F.	Work done on Y in raising it from N to H.
246. (1.30)	Acceleration of X in rolling down the incline toward L.	Acceleration of Y in rolling down the incline toward O.
247. (1.30)	Time it takes X to roll to L.	Time it takes X to fall to M.
248. (1.30)	Force needed to raise X from M to F.	Force needed to raise Y from N to H.

249. When air from a compressed air tank expands, the air
(1.30) is reduced in temperature mainly because

- **A.** convection takes place.
- **B.** work is done at the expense of heat energy.
- **C.** air is a good conductor of heat.
- **D.** expansion increases the degree of molecular freedom.
- **E.** the pressure of a gas is inversely proportional to the absolute temperature.

250. A machine or engine that operates with 100% efficiency
(1.30) involves a process that

- **A.** is reversible.
- **B.** permits no heat energy to escape with the exhaust.
- **C.** involves only perfect gases.
- **D.** uses only 100% pure substances.
- **E.** operates at a temperature of absolute zero.

251. If an electrical generator is turned by hand it is found
(1.30) that it is much more difficult to turn if the terminals of the generator are connected by a wire than if they are not so connected. This is an illustration of

- **A.** the Law of Conservation of Mass.
- **B.** Faraday's Laws. **C.** the Law of Divided Circuits.
- **D.** the Law of Conservation of Energy.
- **E.** Avogadro's Laws.

252. Early in 1905, the possibility of an atomic bomb had
(1.30) been forecast in the work of Dr. Albert Einstein. His suggestion was that

- **A.** matter and energy were separate and distinct from one another.
- **B.** while matter and energy were not entirely separate and distinct, they could not be changed one into another.
- **C.** matter and energy were not separate and distinct, and they could be changed one into another.
- **D.** although energy could possibly be derived from matter, the amount of energy that could possibly be so derived would be of little consequence.
- **E.** while matter and energy were both separate and distinct, it was likely that energy could be converted into great quantities of matter.

253. Experimentally it is possible to
(1.30)

- **A.** convert heat completely into mechanical work.
- **B.** convert mechanical energy completely into heat.
- **C.** create possibly an impractical but nevertheless a 100% efficient engine.
- **D.** completely transform any type of energy into any other one.
- **E.** convey heat from one body to another at a higher temperature.

254. From facts and principles previously established, one
(1.30) can validly infer that

- a. if two prime movers perform the same amount of work, then the prime mover which operates at the greatest horsepower will perform the work in the longer time interval.
- b. to perform equal amounts of work, a prime mover which operates at 100 horsepower would require twice as much time as a prime mover which operates at 200 horsepower.
- c. in a given time interval, a prime mover which operates at 25 horsepower will perform half as much work as a prime mover operating at 50 horsepower.

The correct selection of valid inferences includes only

A. a. **B.** b. **C.** c. **D.** a and b. **E.** b and c.

255. A body at rest is capable of performing work if
(1.30)

- **A.** its potential energy is greater than zero.
- **B.** it has any potential energy whether greater or less than zero.
- **C.** its potential energy is less than its kinetic energy.
- **D.** it is free to move in such a way that its potential energy will diminish.
- **E.** it is free to move in such a way that its potential energy will increase.

256. (2.10) A 170 lb. man climbing vertically 40 feet in 60 seconds develops approximately (33,000 ft.-lbs. per minute = 1 h. p.)

A. 0.1 h. p. **B.** 0.2 h. p. **C.** 0.5 h. p.
D. 1.0 h. p. **E.** 2.6 h. p.

257. (2.10) Machine A, when working to full capacity is capable of lifting a heavy weight to a height of 50 feet in half the time that Machine B, when working to full capacity is able to lift the same weight to the same height. Machine A is, therefore, described as having twice as much

A. potential energy as Machine B.
B. force as Machine B. **C.** mass as Machine B.
D. power as Machine B.
E. kinetic energy as Machine B.

258. (2.10) Water has a density of 62.4 lbs. per cubic foot. If the specific gravity of a piece of cork is .25, a cubic foot of cork weighs

A. 15.6 lbs. **B.** 46.8 lbs. **C.** 62.15 lbs.
D. 78 lbs. **E.** none of these answers.

259. (2.10) Water has a density of 62.4 lbs. per cubic foot. A certain sample of ore has a specific gravity of 2.5. Therefore its density is

A. 2.5 lbs. per cu. ft. **B.** 2.5 grams per cu. ft.
C. 24.76 lbs. per cu. ft. **D.** 64.9 lbs. per cu. ft.
E. 156 lbs. per cu. ft.

260. (2.10) If the density of a substance is 9 grams per cu. cm., its specific gravity is (density of water is 62.4 lb. per cu. ft.)

A. 9 gm. per cm.^{3} **B.** 9 **C.** 9 lb. per cu. ft.
D. 561.6 **E.** 561.5 lb. per ft.^{3}

261. (2.10) The work done by a 20 horsepower engine in 10 minutes is (550 ft./lb./sec. = 1 H.P.)

A. 2.18 ft. lb. **B.** 11,000 ft. lb. **C.** 12,000 ft. lb.
D. 110,000 ft. lb. **E.** none of these.

262. (2.10) A ten-pound weight is dropped from a tall building. At the end of two seconds its kinetic energy is

A. 320 ft. lbs. **B.** 2048 ft. lbs. **C.** 640 ft. lbs.
D. 1280 ft. lbs. **E.** 1000 ft. lbs.

263. (2.10) According to the physical definition of work, a situation in which work is being done is

A. a meteor of certain mass moves 4 miles through space with a constant speed of 5 miles per second.
B. the product of the centripetal force times the circumference of the path in uniform circular motion.
C. a man pushes against a lawn mower with a force of 10 lbs. when it is stuck against a stone.
D. a wooden prop 4 feet long holds up a corner of a building weighing 20 tons.
E. a piece of rock is thrown 100 feet into the air by a volcano.

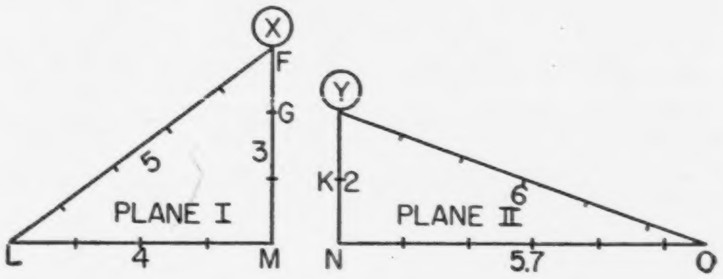
The numbers preceding the paired items in the exercise below refer to the corresponding numbers on the answer sheet. Considering each pair from the standpoint of quantity, blacken space

A. if the item at the left is greater than that at the right.
B. if the item at the right is greater than that at the left.
C. if the two items are of essentially the same magnitude.

264. (2.10)	Work required in climbing a steep hill.	....	Work required in climbing the same hill along a longer and less steep path.
265. (2.10)	Useful work obtained from any actual machine.	....	Energy input of the machine needed to produce the useful work.
266. (2.10)	Work required to roll a barrel up an inclined plane.	....	Work required to raise the barrel vertically through the same vertical distance.
267. (2.10)	Work required to raise a 10-pound object at a vertical height of 30 feet.	....	Potential energy of the 10-pound object dropped 30 feet the instant before it strikes the earth.
268. (2.10)	Potential energy of an object at a height of 30 feet.	....	Kinetic energy of the same object the instant before it strikes the earth.
269. (2.10)	The mechanical advantage of an inclined plane 40 feet long with a vertical height of 2 feet.	....	The mechanical advantage of an inclined plane 60 feet long with a vertical height of 2 feet.
270. (2.10)	Force necessary to propel a 3,000-pound car up an inclined plane 40 feet long with a vertical height of 2 feet.	....	Force necessary to propel the same car up an inclined plane 60 feet long with a vertical height of 2 feet.
271. (2.10)	The amount of energy required to move an object with a crowbar, neglecting friction.	....	The work accomplished in moving the object with the crowbar, neglecting friction.
272. (2.10)	The distance traveled by the effort force in moving the object with the crowbar.	....	The distance traveled by the resisting force in being moved by the crowbar.
273. (2.10)	Heat absorbed by the cooling unit in an electrical refrigerator.	....	Heat liberated in the compressor and cooling coils of the refrigerator.
274. (2.10)	The force of attraction between water molecules in the liquid state.	....	The force of attraction between water molecules in the vapor state.
275. (2.10)	Insulating ability of a good conductor of heat, such as silver.	....	Insulating ability of a poor conductor of heat, such as celotex.
276. (2.10)	The calories of heat required to change one gram of water into steam at the boiling point.	....	The calories of heat liberated when one gram of steam condenses at 100°C.

After the number on the answer sheet corresponding to that of each of the following paired items, blacken space

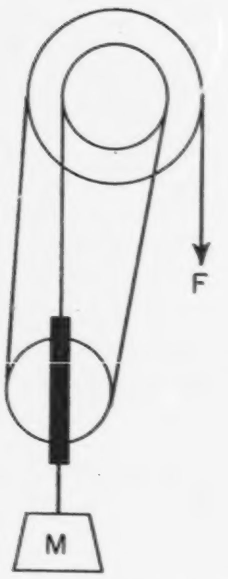
A. if the item at the left is of greater magnitude than the item at the right.
B. if the item at the right is of greater magnitude than the item at the left.
C. if the two items are of equal magnitude.



Two spheres, *X* and *Y*, of equal masses and radii are placed on two inclined planes, as shown in the diagram. Neglect friction and air resistance, and assume that potential energy is measured from the level of points *L*, *M*, *N*, and *O*.

277. (2.10)	Potential energy of *X* at *F*.	Potential energy of *X* at *H*.
278. (2.10)	Potential energy of *X* at *M*.	Potential energy of *Y* at *N*.
279. (2.10)	Kinetic energy of *X* on rolling to *L*.	Kinetic energy of *X* on falling to *M*.
280. (2.10)	Kinetic energy of *X* on rolling to *L*.	Kinetic energy of *Y* on rolling to *O*.
281. (2.10)	Work done on *X* in raising it from *M* to *F*.	Work done on *X* in moving if from *L* to *F*.
282. (2.10)	Work done on *X* in raising it from *M* to *F*.	Work done on *Y* in raising if from *N* to *H*.
283. (2.10)	Acceleration of *X* in rolling down incline toward *L*.	Acceleration of *Y* in rolling down incline toward *O*.
284. (2.10)	Acceleration of *X* in falling vertically toward *M*.	Acceleration of *Y* in falling vertically toward *N*.
285. (2.10)	Gain of kinetic energy of *X* in falling to *G*.	Loss of potential energy of *X* in falling to *G*.
286. (2.10)	Power required to raise *Y* from *N* to *H* in two seconds.	Power required to raise *X* from *M* to *F* in one second.
287. (2.10)	Force needed to raise *X* from *M* to *F*.	Force needed to move *X* from *L* to *F*.
288. (2.10)	Force required to move *X* along incline from *L* to *F*.	Force required to move *Y* along incline from *O* to *H*.
289. (2.10)	Mechanical advantage of Plane I.	Mechanical advantage of Plane II.
290. (2.10)	Work expended on *X* in lifting it from *M* to *F*.	Energy recoverable from *X* when at *F*.

A block and tackle such as shown requires a force *F* of 150 lbs. to raise a mass *M* of 300 lbs.



291. The ideal mechanical advantage is
(2.10)

A. 3. **B.** 2. **C.** 4. **D.** 2½. **E.** 1.

292. The efficiency is
(2.10)

A. 50%. **B.** 66⅔%. **C.** 80%. **D.** 92%. **E.** 75%.

293. If the pulley to which M is attached weighs 30 lbs.,
(2.10) the force required to overcome friction is

A. 40 lbs. **B.** 20 lbs. **C.** 90 lbs. **D.** 10 lbs. **E.** 6⅔ lbs.

294. The specific gravity of aluminum is 2.6. The weight of
(2.10) 5 cu. ft. of aluminum is about

A. 812.5 lbs. **B.** 5 lbs. **C.** 130 lbs. **D.** 13 lbs. **E.** 32.5 lbs.

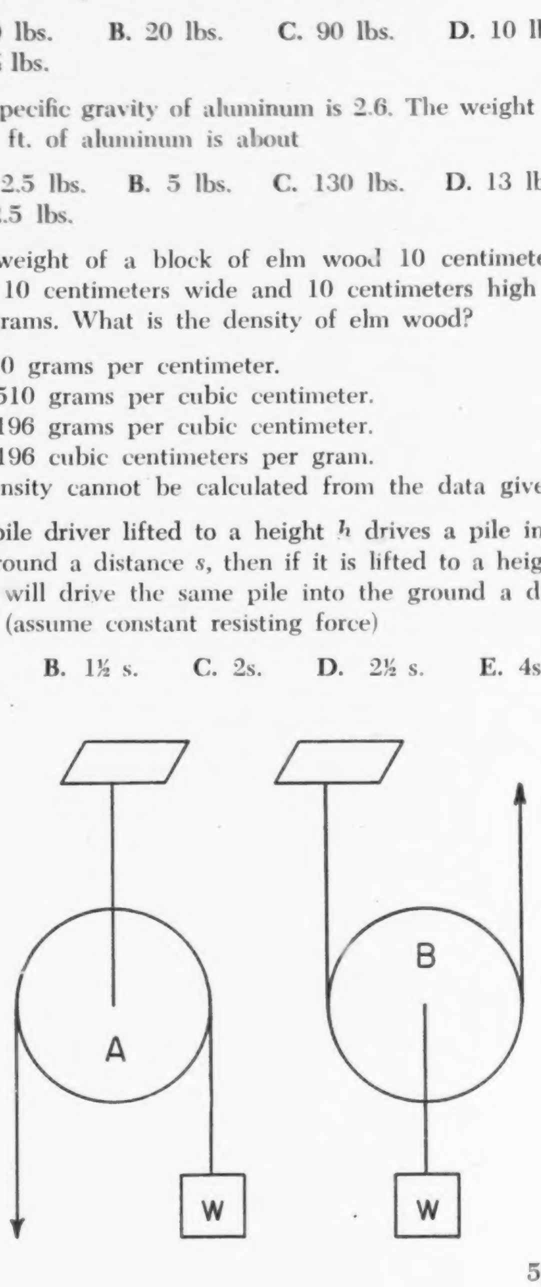
295. The weight of a block of elm wood 10 centimeters
(2.10) long, 10 centimeters wide and 10 centimeters high is 510 grams. What is the density of elm wood?

A. 510 grams per centimeter.
B. 0.510 grams per cubic centimeter.
C. 0.196 grams per cubic centimeter.
D. 0.196 cubic centimeters per gram.
E. density cannot be calculated from the data given.

296. If a pile driver lifted to a height *h* drives a pile into
(2.10) the ground a distance *s*, then if it is lifted to a height *2h* it will drive the same pile into the ground a distance (assume constant resisting force)

A. s. **B.** 1½ s. **C.** 2s. **D.** 2½ s. **E.** 4s.

Item 297.



297. (2.20) In the diagram on the preceding page, the ideal mechanical advantage of machine A is

A. equal to that of B. **B.** twice that of B.
C. one-half that of B. **D.** many times that of B.
E. only a very small fraction of that of B.

298. (2.20) A given mass of gas is enclosed in a suitable container so that it may be maintained at constant volume. This procedure necessarily implies that there can be no change in

A. density. **B.** pressure.
C. molecular kinetic energy. **D.** total heat content.
E. temperature.

299. (3.00) Gold has a specific gravity of 19.3. What is the weight, in grams, of 10 cubic centimeters of gold?

A. 19.3. **B.** 193. **C.** 393. **D.** 493. **E.** 593.

Items 300 and 301 refer to the following data. Water flows over a dam at the rate of 200 cubic feet per minute. The vertical distance from the top of the dam to the turbine site at the bottom of the dam is 80 feet.

). 0) How much work can the waterfall do in one minute at the turbine site, if all the work possible is performed? The answer, in foot-pounds, is approximately

A. 2,000,000. **B.** 1,000,000. **C.** 16,000.
D. 12,500. **E.** 80.

301. (3.00) At what average horse-power could the waterfall do work, if all the work possible is performed?

A. 1. **B.** 30.3. **C.** 15.1. **D.** 60.6 **E.** 0.5.

Items 302 and 303 refer to the following data. A certain 60-watt light bulb is designed to operate 120 volts potential difference.

302. (3.00) When operating at rated voltage, about what current (in amperes) flows through the lamp?

A. 60. **B.** 2. **C.** 240. **D.** 7200. **E.** ½.

303. (3.00) About what is the resistance (in ohms) of the lamp filament?

A. 240. **B.** 2. **C.** 60. **D.** 7200. **E.** ½.

304. (3.00) When water is being pumped into an elevated tank, the least work will be required when the water is pumped in at

A. the top of the tank.
B. the bottom of the tank.
C. the midpoint of the side of the tank.
D. any place along the side of the tank.
E. it is immaterial where the water is pumped in; the work required will be the same in all cases.

305. (3.00) A certain mass of an ideal gas has 12,000 foot-pounds of random molecular kinetic energy at 400° Absolute temperature. What is the greatest amount of mechanical work (in foot-pounds) which the gas could perform when its temperature falls to 300° Absolute temperature?

A. 8000. **B.** 9000. **C.** 3000. **D.** 4000.
E. 12000.

Items 306 and 307 refer to the following data. A piece of metal weighs 100 gm. in air, 60 gm. in water, and 70 gm. when immersed in gasoline. (The density of water is 1 gm./cm.^{3})

306. (3.00) The specific gravity of the above metal is

A. 0.6. **B.** 2.5. **C.** 3.3. **D.** 10.0.
E. none of these.

307. (3.00) The volume of gasoline displaced by the above piece of metal is

A. 10 cm.^{3} **B.** 30 cm.^{3} **C.** 40 cm.^{3}
D. 50 cm.^{3} **E.** none of these.

308. (3.00) A mineral specimen weighs 300 gm. in air, 180 gm. when submerged in water, and 210 gm. in gasoline. The volume of gasoline displaced by the mineral is

A. 30 cm.^{3} **B.** 90 cm.^{3} **C.** 120 cm.^{3}
D. 150 cm.^{3} **E.** none of these.

309. (3.00) The density of the specimen in the preceding question is

A. 1.67 gm./cm.^{3} **B.** 3.33 gm./cm.^{3}
C. 0.40 gm./cm.^{3} **D** 10.0 gm./cm.^{3}
E. none of these.

310. (3.00) If an object floats in water with exactly one-half its volume submerged, the specific gravity of the object

A. cannot be determined unless the total volume is known.
B. cannot be determined unless the weight is known.
C. is one-half. **D.** is one. **E.** is two.

Items 311 - 315 refer to the following data. A piece of rock weighs 100 gm. in air. When it is immersed in water, the buoyancy force is 40 gm. and when it is immersed in an unknown liquid it weighs only 70 gm.

For items 311 - 313 select from the key the correct numerical value of the answer.

KEY

A. 30. **B.** 40. **C.** 60. **D.** 70.
E. none of these.

311. (3.00) The weight in gm. of the water displaced.

312. (3.00) The volume in cm.^{3} of the unknown liquid displaced.

313. (3.00) The volume of the rock in cm.^{3}

314. (3.00) The specific gravity of the unknown liquid is

A. .30. **B.** .57. **C.** .70. **D.** .75.
E. some other value.

315. (3.00) The density of the rock is

A. less than 62.4 lb./ft.^{3} **B.** 1.75 gm./cm.^{3}
C. 2.50 gm./cm.^{3} **D.** 1.67 gm./cm.^{3}
E. some other value.

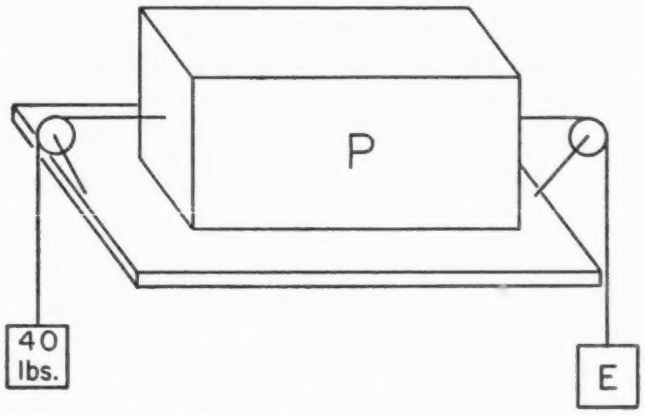
316. (3.00) The work done in moving a 50 lb. sled 10 ft. horizontally when a force of 20 lb. is applied at an angle of 60° with the horizontal is

A. 100 ft. lb. **B.** 200 ft. lb. **C.** 500 ft. lb.
D. 1000 ft. lb. **E.** none of these.

317. (3.00) If a block of ice at 32°F. is floated on the surface of ice water in a tumbler, the water coming just to the brim of the tumbler after the ice has been floated, on melting of the ice

A. the water will overflow the tumbler.
B. the water level will not change.
C. the water level will fall.
D. it is necessary to have more information before the problem may be solved.

Items 318 - 320 refer to the following diagram



318. (3.00) In the accompanying sketch the box, P, contains some kind of mechanism. If this mechanism is more than 80% efficient and a force of 10 pounds at E raises the 40-pound weight 100 feet for every 450 feet E moves then the box P must contain some mechanism that

A. has an ideal mechanical advantage less than 1.
B. has an ideal mechanical advantage greater than 1.
C. is a source of energy. **D.** is a source of power.
E. converts heat into mechanical energy.

319. (3.00) If in the above diagram the box contains a machine such that a force of 20 pounds at E moves the 40-pound weight 10 feet for every 32 feet the force moves, then the efficiency of the machine in the box is within 10% of

A. 10%. **B.** 30%. **C.** 50%. **D.** 70%. **E.** 90%.

320. (3.00) If one foot pound of work is done at E and the 40-pound weight rises 10 feet then the box contains a machine that

A. has a mechanical advantage less than 1.
B. has a mechanical advantage greater than 1.
C. is a source of energy. **D.** has low efficiency.

321. (3.00) K. E. = $\frac{1}{2}Mv^2$ for a body moving in a straight line. The analogous formula for the kinetic energy of a rotating body is K. E. = $\frac{1}{2} I W^2$, where I is the moment of inertia which increases the farther the mass is concentrated from the point of rotation (e.g., a wheel has most of its mass concentrated in the rim). W is the angular velocity in radians per second.

A body may possess rotational kinetic energy as well as linear but the total energy remains constant.

Suppose three objects a, b, c of equal masses were allowed to go down a frictionless plane:

a. A metal block sliding down.
b. A wheel rolling down.
c. A solid cylinder (same diameter as the wheel) rolling down.

Which object will win the race if released at the same time from the same height?

A. The block. **B.** The wheel. **C.** The cylinder.
D. The race will be a tie.

Items 322 - 324 refer to the experimental use of a pycnometer (specific gravity bottle). In this case the object was to determine the density of an unknown solid in the form of small shot which could be poured into the bottle. Assume that the density of water is 1 gm./cm.^{3} The following data were collected:

Weight of bottle	18.3 gm.
Weight when filled with water	43.3 gm.
Weight when partly filled with shot	67.2 gm.
Weight with shot and water to fill the crevices	77.3 gm.

322. (3.00) The volume of shot used was

A. 25 cm.^{3} **B.** 14.9 cm.^{3} **C.** 48.9 cm.^{3}
D. 10.1 cm.^{3} **E.** none of these.

323. (3.00) The density of the unknown shot in gm./cm.^{3} was calculated by

A. 48.9/25. **B.** 48.9/10.1. **C.** 48.9/14.9.
D. 67.2/14.9. **E.** none of these.

324. (3.00) The best explanation of the use of a stopper with a hole through the center is that

A. it helps to prevent breakage if hot water is used.
B. it allows for expansion when the temperature changes.
C. it permits complete filling of the bottle.
D. it helps to remind the student to keep the bottle upright while weighing.
E. admits air to the top of the water surface.

Some boys playing with a floating rectangular raft noticed that it projected 1/10 ft. out of water, but when they got on it, the raft just barely floated. The combined weight of the boys was 187.5 lbs. The density of water is 62.5 pounds per cubic foot.

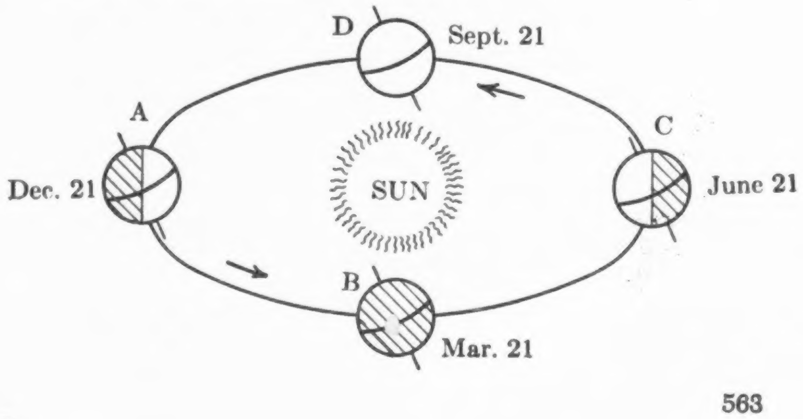
325. (3.00) When the boys got on the raft, the additional volume of water displaced was

A. 18.75 cu. ft. **B.** .30 cu. ft. **C.** 3.0 cu. ft.
D. 30 cu. ft. **E.** none of these.

326. (3.00) The area of cross section of the raft must have been

A. 3 sq. ft. **B.** 30 sq. ft. **C.** 6.25 sq. ft.
D. 18.75 sq. ft. **E.** none of these.

After each item number on the answer sheet, blacken the one lettered space which designates the part of the diagram to which the item correctly refers. If the item refers to all of the labeled positions, blacken the space E.



Note that if it were not for the earth's orbital motion the earth would fall toward the sun.

327. (3.00) The potential energy of the earth with respect to the sun is greatest.

328. (3.00) The kinetic energy of the earth near this position is least.

329. The potential energy of the earth with respect to the sun is at a minimum.

330. (3.00) The kinetic energy of the earth near this position will be at a maximum.

331. (3.00) The sum of the potential energy and the kinetic energy is constant.

332. (3.00) The position at which the earth is receiving the maximum amount of radiant energy from the sun.

333. (3.00) If a child pulls a 20 lb. sled with a rope making a 12° angle with the horizontal and he exerts a 10 lb. force on the rope, the horizontal component of the force is

A. 2.1 lbs. **B.** 9.8 lbs. **C.** 19.6 lbs.
D. 29.3 lbs. **E.** 10.4 lbs.

334. (3.00) Gold can be beaten so thin that a square piece of leaf 10 cms. on a side weighs 0.0193 gram. The density of gold being 19.3 gms./cc., the thickness of the leaf is

A. less than 10^{-7} cm. **B.** greater than 10^{-3} cm.
C. between 10^{-6} cm. and 10^{-3} cm.
D. between 5×10^{-4} and 10^{-3} cm.
E. between 10^{-6} and 10^{-7} cm.

335. (3.00) An elastic ball of mass ⅓ pound strikes a movable elastic wall. The speed of the ball before impact is 96 feet per second toward the wall, and after impact is 32 feet per second away from the wall, the motion of the ball being always perpendicular to the wall. If the loss in kinetic energy was used entirely in doing work on the wall, how much work was done in foot-pounds?

A. 72. **B.** 64. **C.** 2048. **D.** 32. **E.** 42.6.

336. (3.00) A car has a mass of 3200 pounds and is moving at a speed of 100 feet per second. Approximately how much heat energy was converted into mechanical energy in giving the car its kinetic energy?

A. 6.4 BTU. **B.** 500,000 BTU. **C.** 20,500 BTU.
D. 641 BTU. **E.** 390,000,000 BTU.

Items 337 - 338. In a steam-engine cylinder during the power stroke, the average total pressure of the expanding steam is 215 pounds per square inch. The area of one face of the piston is 50 square inches, the length of the power stroke is 2 feet, and the number of power strokes per minute is 180. Assume the exhaust is at atmospheric pressure.

337. (3.00) The *useful* work done on the piston by the expanding steam is, in foot-pounds,

A. 20,000. **B.** 400. **C.** 430. **D.** 10,000.
E. 21,500.

338. (3.00) The useful power developed by the engine is, in horse-power,

A. 2.4. **B.** 109. **C.** 117. **D.** 55. **E.** 6540.

Items 339 - 340. A body having a mass of 200 pounds falls from a height of 1000 feet.

339. (2.10) How much potential energy in foot-pounds does the body have at a height of 400 feet?

A. 80,000. **B.** 120,000. **C.** 400. **D.** 2500.
E. 200,000.

340. (2.10) How much kinetic energy in foot-pounds has the body acquired by the time it has fallen to a height of 400 feet?

A. 80,000. **B.** 120,000. **C.** 600. **D.** 2500.
E. 200,000.

341. (3.00) A certain mass of an ideal gas has 5000 foot-pounds of random molecular kinetic energy at 1000° Absolute temperature. What is the greatest possible amount of mechanical work, in foot-pounds, which the gas could perform as its temperature falls to 800° Absolute?

A. 1000. **B.** 2000. **C.** 3000. **D.** 4000.
E. 5000.

342. (4.10) To standardize the concentration of a salt solution by adding salt until the solution will float an egg is based on the assumption that

A. all eggs have equal volume.
B. all eggs have equal weight.
C. all eggs have equal density.
D. all eggs are about the same shape.

343. (4.20) If two objects, A and B, have the same momentum, B can have more kinetic energy than A only if it

A. weighs more than A. **B.** is moving faster than A.
C. weighs the same as A.
D. is moving more slowly than A.
E. occupies a position above that of A.

Items 344 - 349 contain pairs of statements which are either in agreement with each other or not in agreement, and either one of the statements may be true or false. For each item select from the key the correct response.

KEY

A. Statement I and II are in agreement and both false.
B. Statement I and II are in agreement and both true.
C. Statement I and II are not in agreement; I true, II false.
D. Statement I and II are not in agreement; I false, II true.

344. (4.20) I. Carbon is always of positive valency.
II. Carbon always lends electrons in chemical reactions.

345. (4.20) I. The activity of rock folding in the lithosphere has never been observed.
II. The deformation (rock folding) takes place too rapidly to be observed.

346. (4.20) I. At absolute zero the molecules of a substance do not move with respect to each other.
II. No heat energy is possessed by a substance at absolute zero.

347. (4.20) I. If an air mass expands isothermally, its temperature will rise.
II. Heat must be added in the isothermal expansion of air.

348. I. If a metal is oxidized its valence is lowered.
(4.20) II. An oxidizing agent lends electrons to the metal it oxidizes.

349. I. Any body having mass possesses inertia.
(4.20) II. The gravitational pull of the earth determines the mass of a body.

350. The center of gravity of any mass seeks the lowest
(4.20) point. The potential energy of any system tends toward a minimum. These statements are

A. equivalent. **B.** closely related, but not equivalent.
C. both correct, but unrelated.
D. mutually contradictory.

15. *Kinetic Theory*

KINETIC THEORY

1. (1.10) The spontaneous process whereby two gases intermingle so as to form a homogeneous mixture is known as

A. cohesion. **B.** sublimation. **C.** condensation.
D. diffusion. **E.** osmosis.

2. (1.10) The Brownian movement was so named because a man named Brown noticed that finely divided solid particles suspended in a liquid moved about continuously. He attributed this to

A. convection currents in the liquid.
B. electrical forces of attraction and repulsion.
C. chemical activity between the substances.
D. molecular movement of liquid particles.
E. Newton's Law of Universal Gravitation.

3. (1.10) The temperature at which water boils may be increased by

A. decreasing the area of exposed surface.
B. insulating the container. **C.** adding salt.
D. raising the gas flame.
E. dissolving alcohol in the water.

4. (1.10) The temperature in a medium refers to

A. the quantity of molecules present.
B. the total potential energy of the molecules.
C. the average kinetic energy of the molecules.
D. the total caloric content of the individual molecules.
E. the average potential energy of the molecules.

For items 5 - 9, indicate the most closely related word or phrase from the key below.

KEY

A. Condensation. **B.** Crystallization.
C. Diffusion. **D.** Distillation. **E.** Evaporation.

5. (1.10) A process in which a liquid is changed to a gas and back again.

6. (1.10) A change of state from a gas to a liquid.

7. (1.10) The formation of a definite arrangement of molecules, atoms, or ions.

8. (1.10) The process by which a substance is equally distributed through all parts of another substance.

9. (1.10) The vapor pressure of a liquid

A. is the pressure at which its pressure is equal to that of the atmosphere.
B. decreases more rapidly with temperature as the temperature falls.
C. is the pressure necessary to cause bubble formation at atmospheric pressure.
D. is the pressure at which the rate of evaporation is equal to the rate of condensation.
E. is normally larger for electrovalent than for covalent compounds.

10. (1.10) When a chemical reaction has reached equilibrium

A. the forward and backward reactions are proceeding at exactly the same speed.
B. the product of the concentrations of the reactants is equal to the product of the concentrations of the resultants.
C. the partial pressure of any gases involved is unity.
D. the addition of a catalyst will displace the reaction in the exothermic direction.
E. chemical reaction of the molecules in the mixture has entirely ceased.

11. (1.10) The value of the equilibrium constant in a given reaction

A. is the same at all temperatures.
B. depends upon the initial concentrations of the reactants.
C. gives the absolute rate of the reaction.
D. is not affected by the presence of catalysts.
E. is the same for all reactions, if the temperature is constant.

12. (1.10) A liquid boils when

A. its vapor pressure equals the vapor pressure of the atmosphere.
B. its vapor pressure equals the pressure of the atmosphere.
C. its pressure equals its vapor pressure.
D. its vapor pressure equals the pressure of the water vapor in the atmosphere.
E. it changes to a gas.

13. (1.10) The absolute zero is considered to be —273°C. because

A. all gases liquefy before that temperature is reached.
B. that is the lowest temperature that has ever been reached experimentally.
C. the Centigrade and Fahrenheit scales come together at that point.
D. Dulong and Petit's law holds at this point.
E. the pressure of a constant volume of gas at 0° decreases $\frac{1}{273}$ for every degree (C.) of temperature decrease.

14. (1.10) The critical temperature of a substance is

A. the temperature required to liquefy the gas at one atmosphere pressure.
B. the temperature at which the substance begins to decompose.
C. the highest temperature at which the substance can be a liquid.
D. the temperature at which the liquid evaporates.
E. the lowest temperature at which the substance may be liquefied.

15. (1.10) Osmosis is

A. another name for dialysis.
B. the flow through a semipermeable membrane of solvent from dilute to concentrated solutions.
C. the flow, as above, from concentrated to dilute solutions.
D. the rise of liquids in tubes by capillary attraction.
E. the flow of ions through the membrane of the primary cell.

16. (1.10) The triple point is defined as the point for which temperature and pressure is such that

A. solid and liquid are in equilibrium.
B. liquid and vapor are in equilibrium.

C. solid and vapor are not in equilibrium.
D. solid, liquid, and vapor are in equilibrium.
E. vapor is condensing into liquid.

17. What is the vapor pressure of water at 100°C.?
(1.10)

A. 0 millimeters of mercury.
B. 4.6 millimeters of mercury.
C. 380 millimeters of mercury.
D. 760 millimeters of mercury.
E. it varies, depending upon the atmospheric pressure.

18. Which of the following is a good definition of the pressure of a gas?
(1.10)

A. The pressure of a gas is the force exerted by the gas against its containing walls.
B. The pressure of a gas is the force exerted by the gas against a unit area of its containing walls.
C. The pressure of a gas is the force exerted upon the gas by its containing walls.
D. Each of the above is a good definition of the pressure of a gas.
E. None of the above is a good definition of the pressure of a gas.

Items 19 - 20 deleted.

21. When the pressure on a given mass of gas is decreased
(1.22a)

A. the molecules of the gas will gain kinetic energy.
B. the temperature of the gas will decrease.
C. more collisions between gas molecules will occur.
D. the volume will decrease.
E. the molecules will move more rapidly.

22. The rate of evaporation of water may be increased by all of these steps except
(1.22a)

A. increasing the temperature.
B. placing the water in a pan of larger diameter.
C. increasing the humidity of the room.
D. decreasing the pressure over the water surface.
E. increasing the molecular motion of the water.

23. A given amount of gas in a closed container is heated from room temperature to 100°C. Assume that the volume of the container remains unchanged. According to the kinetic theory, the
(1.22a)

A. gas has increased in weight.
B. individual molecules of the gas have increased in size.
C. average distance between molecules has increased.
D. average velocity of the molecules has increased.
E. pressure on the sides of the container has decreased.

24. Increasing the temperature of a confined gas would
(1.22a)

A. decrease the pressure if the volume is also decreased.
B. increase the pressure if the volume were held constant.
C. increase the pressure if the volume were also increased.
D. increase the volume if the pressure were also increased.
E. decrease the volume if the pressure were also decreased.

25. When a given mass of gas is heated while its volume is held constant,
(1.22a)

A. the gas condenses to a liquid.
B. the pressure of the gas decreases.
C. the pressure of the gas remains the same.
D. the kinetic energy of the molecules will be reduced.
E. the molecules will move faster.

26. One can infer that the cooling of any substance results in a decrease in the
(1.22a)

A. weight of the molecules.
B. decomposition of the molecules.
C. volume of the molecules.
D. number of collisions between the molecules.
E. attractive forces between the molecules.

27. When the molecules of a confined gas are made to move faster,
(1.22a)

A. the volume of the gas decreases.
B. the temperature of the gas decreases.
C. the temperature of the gas remains constant.
D. the temperature of the gas increases.
E. the gas condenses to a liquid.

28. According to the Law of Molecular Concentrations, the rate of a chemical action is directly proportional to
(1.22a)

A. the product of the molecular concentrations of the reacting substances.
B. the sum of their molecular concentrations.
C. the product of their masses.
D. the product of their percentage concentrations.
E. the absolute temperature.

29. According to Arrhenius, the values of the depression of the freezing point were determined by Raoult for 1 per cent solutions. The values of *i* tabulated in Arrhenius' next-to-last column were obtained by
(1.20)

A. dividing the measured freezing point depressions by 18.5.
B. dividing 18.5 by the measured freezing point depressions.
C. calculating the freezing point depressions for solutions containing 1 mol of solute per 100 gm of water and dividing by 18.5.
D. calculating the freezing point depressions for solutions containing 1 mol of solute per 100 gm, and dividing 18.5 by the result.
E. calculating the freezing point depressions for solutions containing 1 mol of solute per 100 gm, dividing by 18.5, and multiplying by the molecular weight of the solute.

30. The pressure of a given saturated vapor depends on
(1.22a)

A. the volume of the space to be filled.
B. the amount of liquid to be vaporized.
C. the density of the liquid only.
D. the temperature only.

31. Which one of the following is the *best observational evidence* for the statement in the kinetic theory that molecules are in continual motion?
(1.24)

A. Convection takes place in gases.
B. Escaping hydrogen gas diffuses throughout a room.
C. Tornadoes are very destructive.
D. Small suspended particles in a solution move about.
E. On collision with the walls of a container, molecules of a gas suffer no net loss of kinetic energy.

32. (1.24) The hypothesis that gases expand and contract because the molecules expand and contract while remaining in contact is best refuted by

A. the observation that all gases are transparent.
B. the observation that gases interdiffuse rapidly.
C. the theory that molecular diameters are constant.
D. the observation that the fog tracks of alpha particles through hydrogen are long and straight.
E. the theory that gases are mostly empty space.

33. (1.25) In a laboratory experiment in which the weight of 22.4 liters of oxygen was determined by collecting the gas over water

A. 22.4 liters of oxygen were collected.
B. the vapor pressure of water was subtracted from the existing atmospheric pressure.
C. the collected oxygen was dried and weighed.
D. it was necessary to decompose all the potassium chlorate originally in the ignition tube.
E. no pressure or temperature corrections were required.

34. (1.22a) When the molecules of a confined gas are made to move faster, the

A. volume of the gas decreases.
B. temperature of the gas decreases.
C. temperature of the gas remains the same.
D. temperature of the gas increases.
E. molecular motion has no effect on the temperature.

35. (1.30) Moving air seems cooler to a person than still air, because

A. moving the air gives it a lower temperature.
B. moisture from the body is evaporated more rapidly.
C. impact of air on the face gives the impression of coolness.
D. moving air has the greater specific heat.
E. still air has the greater specific heat.

36. (1.30) Reducing the pressure in the space over a liquid will

A. reduce the rate of escape of molecules from the liquid.
B. raise the temperature of the liquid.
C. lower the freezing point of the liquid.
D. lower the boiling point of the liquid.
E. increase the kinetic energy of the molecules of the liquid.

Mark items 37 - 39 according to the key below. (Assume an ideal gas.)

KEY

A. True without qualification. **B.** False.
C. True if the temperature is constant.
D. True if the volume is constant.
E. True if the pressure is constant.

37. (1.30) The pressure of a gas varies directly as the volume.

38. (1.30) The pressure of a gas varies directly as the absolute temperature.

39. (1.30) The volume of a gas varies inversely as the pressure.

40. (1.30) The individual molecules of a substance which changes from a gas to a liquid to a solid, experience the greatest change in their

A. kinetic energy. **B.** mass. **C.** potential energy.
D. volume. **E.** coefficient of expansion.

41. (1.30) All of the following would be contradictory to the kinetic theory except

A. a gas that liquefies at 300° below zero Centigrade.
B. two solids that diffuse into each other.
C. a greater force of attraction between two molecules of steam at 212°F. than between two molecules of water at the same temperature.
D. a material in which all molecular motion stops at 0°C.
E. a solid which evolves heat as it changes to a liquid.

Items 42 - 48 refer to the kinetic-molecular theory. After each item number on the answer sheet, blacken space

A. if the item refers to observational or experimental evidence which supports the theory.
B. if the item refers to an hypothesis or an assumption concerning the theory which was formulated long before there was experimental evidence to test it, or has not as yet been entirely proven to be true experimentally.
C. if the item refers to something which has nothing to do with the theory.

42. (1.30) The volume of a gas increases with an increase in temperature when the pressure remains constant.

43. (1.30) A gas always exerts pressure no matter how much it expands.

44. (1.30) Most gases are colorless.

45. (1.30) Gases are composed of small particles called molecules which are relatively far apart and in rapid motion.

46. (1.30) Gases diffuse readily.

47. (1.30) Molecules are perfectly elastic.

48. (1.30) Molecules on colliding lose no energy.

49. (1.30) When a given mass of gas is heated while its volume is held constant

A. the gas condenses to a liquid.
B. the pressure of the gas decreases.
C. the pressure of the gas remains the same.
D. the kinetic energy of the molecules will decrease.
E. the molecules will move faster.

50. (1.30) The force exerted on the walls of a vessel by a contained gas is caused by

A. the repulsive forces between the molecules.
B. slight loss in average speed suffered by the molecules at the walls.
C. changes in the momentum which the molecules experience at the walls.
D. attraction between the walls and the gas.
E. elastic collisions between molecules of the gas.

51. (1.30) The pressure exerted on the walls of a vessel by a confined gas arises from

A. the repulsion between molecules.
B. a loss in speed when the molecules hit the walls.
C. the attraction of the walls for the gas molecules.
D. the stored-up energy of the molecules.
E. the kinetic energy of the molecules.

52. (1.30) The amount of evaporation of water into the air of a room may be decreased by

- **A.** increasing the temperature.
- **B.** placing the water in a pan of larger diameter.
- **C.** increasing the humidity of the room.
- **D.** decreasing the pressure over the water surface.
- **E.** increasing the molecular motion of the water.

53. (1.30) The best explanation for the nearly spherical shape of raindrops is based on

A. evaporation. **B.** gravity. **C.** capillary action.
D. the Brownian movement. **E.** surface tension.

54. (1.30) To state that the volume of a gas changes by 1/273 for each degree Centigrade change in temperature can be true only if

- **A.** the volume is expressed in metric units.
- **B.** the gas consists of only one element or compound.
- **C.** the change in temperature is decreasing.
- **D.** the temperature is expressed in Absolute rather than in Centigrade degrees.
- **E.** no chemical reaction is caused.

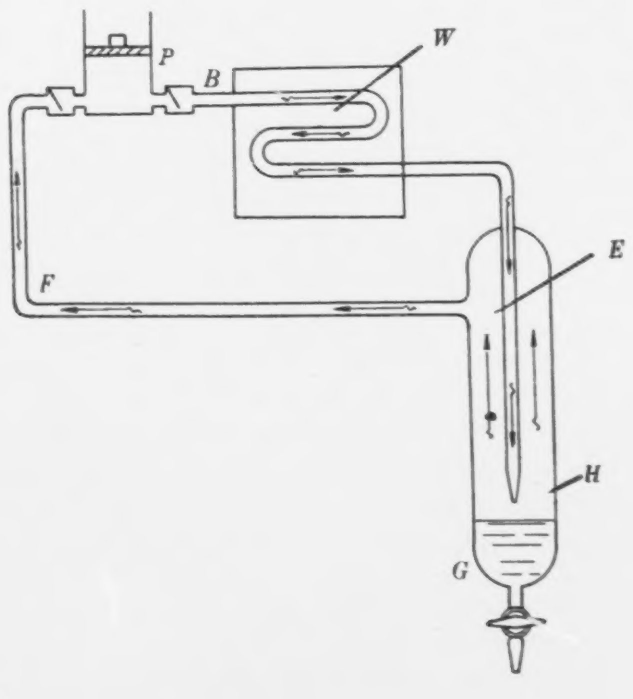
55. (1.30) The principle of most direct significance in the operation of mechanical refrigeration is that

- **A.** evaporation is a cooling process.
- **B.** it is impossible to convert heat wholly into work.
- **C.** cooling results when a vapor expands against the attractive forces between the molecules.
- **D.** the volume occupied by a given mass of gas is inversely proportional to the pressure applied.
- **E.** none of the above applies to refrigerators.

56. (1.30) The kinetic theory can be used to explain all of the following phenomena except

- **A.** the difference in riding quality between a flat and a properly inflated tire.
- **B.** the presence of cooking odors in rooms adjacent to a kitchen.
- **C.** Boyle's Law. **D.** Charles' Law.
- **E.** artificially induced radioactivity.

Items 57 - 60 refer to the liquefaction of air.



In the Linde process for making liquid air, the gas, thoroughly freed from water vapor, is first compressed to a high pressure (some 2000 lbs./in.^{2}) by a pump (P in the diagram). It is then cooled in an ice-water bath W. The cool air then passes into an expansion chamber E, being driven through the inner of two tubes and escapes at the bottom through a small adjustable hole H. It is drawn back through the outer tube by the suction side of the double-acting pump. The expansion cools the air. Thus the incoming stream of air is cooled by the outgoing one, and this cooling process is progressive, so that, if heat is prevented from getting into the expansion chamber from outside, the expanding air eventually cools itself to a temperature below its boiling point, when drops of liquid form by condensation and fall into the vacuum vessel at the bottom, where it is kept until needed.

57. (1.30) Which of the following occurs when the incoming air is compressed?

- **A.** The temperature of the air increases.
- **B.** Power is produced to run generators.
- **C.** The air is immediately liquefied.
- **D.** The temperature of the air decreases.
- **E.** Oxygen is separated from nitrogen.

58. (1.30) The cooling effect of the expansion of the air is a phenomenon which

- **A.** occurs only because the temperature is already at a low point.
- **B.** is a peculiarity of air.
- **C.** occurs because the gas was originally under a low pressure.
- **D.** is caused by a liquefaction of part of the air.
- **E.** occurs when any gas expands.

59. (3.00) The principal reason for removing water vapor from the incoming air is to

- **A.** produce pure liquid air.
- **B.** prevent formation of rust in the apparatus.
- **C.** prevent formation of steam which would cause deterioration of the piston in P.
- **D.** prevent formation of ice which would cause the water in W to change to ice.
- **E.** prevent formation of ice which would clog the air tubes.

60. (1.10) The main purpose for the liquefaction of air is to

- **A.** produce nitrogen for commercial use.
- **B.** produce oxygen for commercial use.
- **C.** produce liquid air for commercial refrigeration.
- **D.** attain extremely low temperatures.
- **E.** demonstrate that air can be liquefied.

61. (1.30) That the volume of an ideal gas is directly proportional to the absolute temperature is

- **A.** an inaccurate expression.
- **B.** true if the centigrade scale of temperatures is used.
- **C.** true if the pressure is held constant.
- **D.** true if the volume is held constant.
- **E.** true without qualification.

62. (1.30) Which one of the following would not affect the volume of a single gas in a rubber balloon?

- **A.** Chemical composition of the gas.
- **B.** Temperature of the gas.
- **C.** Pressure of the gas.
- **D.** Altitude of the balloon.
- **E.** More than one of the above.

63. The particles of which all matter is composed are believed to be
(1.30)

- **A.** moving at the same rate regardless of the mass or physical state of the matter.
- **B.** moving at different rates, the differences depending on the quantity or mass of the matter.
- **C.** moving at different rates, the differences depending on the physical state and temperature of the matter.
- **E.** moving at different rates, the differences depending on the weight of the matter observed.
- **E.** stationary and immovable.

64. Of the following concerning the kinetic theory the one which is incorrect is:
(1.30)

- **A.** Matter is comprised of small discrete particles called molecules.
- **B.** Molecules are in motion in all substances except at the temperature of absolute zero.
- **C.** For gases it is assumed that molecules are very far apart in relation to the size of the molecules.
- **D.** For gases it is assumed that molecules exert practically no attraction on each other.
- **E.** None of the above is incorrect.

65. Indicate which of the following items is most nearly correct with respect to the difference between a gas and a liquid.
(1.30)

- **A.** Gases are invisible, liquids are visible.
- **B.** Gases can be greatly compressed, liquids cannot.
- **C.** Molecules of a gas are smaller than molecules of a liquid.
- **D.** Molecules of a gas will diffuse, molecules of a liquid will not.
- **E.** Molecules of a gas have a higher kinetic energy than the molecules of a liquid at the same temperature.

66. At constant temperatures, volume varies inversely with pressure for enclosed
(1.30)

A. solids, liquid, and gases. **B.** solids and liquids.
C. solids and gases, but not liquids. **D.** liquids.
E. gases.

67. Which one of these is *not* a characteristic of a gas molecule in motion?
(1.30)

- **A.** Very high velocities.
- **B.** A vast number of collisions per second.
- **C.** A speed directly proportional to the mass of the molecule.
- **D.** Motion in straight lines between collisions.
- **E.** Erratic motion as exemplified in the Brownian movement.

68. If two miscible liquids are placed in contact without stirring, one will
(1.30)

- **A.** remain separate from the other.
- **B.** slowly diffuse into the other.
- **C.** coalesce, and the liquids separate into different layers.
- **D.** form an immediate mixture with globules of the other.
- **E.** evaporate before the other.

69. The expansion of a solid on heating is due to
(1.30)

- **A.** an increase in the size of the particles of the solid.
- **B.** an increase in the agitation of the particles of the solid.
- **C.** the addition of caloric to the solid.
- **D.** application of the kinetic-molecular theory.
- **E.** none of the above.

70. The attractive forces between molecules become *less* when
(1.30)

- **A.** temperature is raised at constant pressure.
- **B.** temperature is lowered at constant pressure.
- **C.** pressure is raised at constant temperature.
- **D.** volume is decreased at constant temperature.
- **E.** volume is decreased at constant pressure.

71. Which of the following is *not* a general property of gases?
(1.30)

- **A.** They mix homogeneously unless they react.
- **B.** When molecules collide with each other, there is no loss of energy in the gas.
- **C.** They are always clear and colorless.
- **D.** The molecular attraction between the molecules is less than it is for liquids and solids.
- **E.** The temperature of a gas is a measure of the average kinetic energy of its molecules.

72. At a constant temperature, the volume of a gas
(1.30)

- **A.** increases as the pressure increases.
- **B.** decreases as the pressure increases.
- **C.** is inversely proportional to the pressure.
- **D.** is directly proportional to the pressure.
- **E.** two of the above are correct.

73. Boyle's Law which states that, at a constant temperature, pressure is inversely proportional to volume, can be applied
(1.30)

A. to all liquids. **B.** to all gases.
C. only to combinations of liquids and gases.
D. to any combination of liquids, gases, and solids.
E. to all of these.

74. In computing the kinetic energy of a gas molecule, it is necessary to consider both the velocity of the molecule as well as
(1.30)

- **A.** its mass.
- **B.** the number of atoms in the gas molecule.
- **C.** the kinds of atoms in the gas molecule.
- **D.** its physical properties. **E.** all of the above.

For items 75 - 84 consider the following statements to apply to the kinetic theory of an ideal gas. Mark space

- **A.** if a statement is true without qualification.
- **B.** if a statement is false without qualification.
- **C.** if a statement may be either true or false depending on some further conditions.

75. When a certain gas is made denser, the molecules are then closer together.
(1.30)

76. When a gas is heated it expands.
(1.30)

77. When a gas is heated its pressure rises.
(1.30)

78. When the temperature of a gas is raised, the average speed of the molecules increases.
(1.30)

79. When molecular collisions are more frequent but the speeds are unchanged, the pressure is greater.
(1.30)

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80. When molecular collisions are more frequent but the
(1.30) speeds are unchanged, the temperature is greater.

81. When the molecules of a gas are crowded closer together, their average speed increases.
(1.30)

82. When a gas is compressed adiabatically, heat is generated by friction between the molecules.
(1.30)

83. When a gas is compressed adiabatically, the average molecular speed increases.
(1.30)

84. When a gas is compressed adiabatically, the pressure increases in direct proportion to the absolute temperature.
(1.30)

85. For which one of the following does the kinetic theory offer the least satisfactory explanation?
(1.30)

- **A.** The growth of crystals.
- **B.** The elasticity of solids.
- **C.** Heat as a form of molecular motion.
- **D.** The magnetization of a magnet.
- **E.** The near incompressibility of liquids and solids.

Items 86 - 98 relate to one of the four theories listed below. After each item blacken the space

- **A.** if the statement belongs to the atomic theory.
- **B.** if the statement belongs to the kinetic theory.
- **C.** if the statement belongs to the theory of ionization.
- **D.** if the statement belongs to the theory of isostacy.

86. Molecules are in constant haphazard motion with velocities which increase with temperature.
(1.30)

87. The number of elements is limited.
(1.30)

88. At absolute zero of temperature the molecules of a substance are stationary.
(1.30)

89. Certain substances such as acids, bases, and salts, when dissolved in water will conduct an electric current.
(1.30)

90. Molecules lose no energy when they collide or rebound.
(1.30)

91. Geosynclines of sedimentation eventually become folded into mountains.
(1.30)

92. The molecules of a substance attract one another.
(1.30)

93. Matter is discontinuous.
(1.30)

94. The charge of an ion is proportional to its valence.
(1.30)

95. The distance between the molecules of a gas is extremely great in comparison to their diameters.
(1.30)

96. Compounds are formed by the union of atoms in simple ratios.
(1.30)

97. Heat is molecular motion.
(1.30)

98. There has been progressive subsidence in the Mississippi deltaic region through long intervals of geologic time.
(1.30)

99. If a saturated vapor is compressed at constant temperature,
(1.30)

- **A.** the pressure rises.
- **B.** the vapor density increases.
- **C.** the vapor begins to condense.
- **D.** the pressure falls.
- **E.** the system obeys Boyle's Law.

100. Substances do not deliquesce unless
(1.30)

- **A.** the vapor pressure of their concentrated aqueous solutions is less than the pressure of the water vapor in the atmosphere.
- **B.** their vapor pressure is less than the pressure of the atmosphere.
- **C.** they form dilute solutions which are saturated.
- **D.** they give off water of hydration.
- **E.** they are present in an atmosphere the humidity of which is 100%.

101. Hydrates effloresce when
(1.30)

- **A.** water is absorbed by them.
- **B.** the vapor pressure of the hydrate is greater than the vapor pressure of the atmosphere.
- **C.** it is less than the vapor pressure of the atmosphere.
- **D.** the pressure of the hydrate is greater than the pressure of the atmosphere.
- **E.** the vapor pressure of the hydrate is greater than the partial pressure of the water vapor in the atmosphere.

102. Van der Waals' forces
(1.30)

- **A.** cause the high melting point of most salts.
- **B.** hold together the atoms in a diamond crystal.
- **C.** disappear when gases are liquefied.
- **D.** are responsible for the liquefaction of covalent compounds.
- **E.** promote the supercooling of liquids.

103. The kinetic-molecular theory
(1.30)

- **A.** is based on the Law of Constant Proportions.
- **B.** was originally derived from observations on crystals.
- **C.** explains why large molecules exert a greater pressure than do the same number of small molecules at the same temperature in the same volume.
- **D.** gives a satisfactory explanation of Charles' Law.
- **E.** explains the Law of Dulong and Petit.

104. Gases, in general, show abnormally large compressibilities
(1.30)

- **A.** at ordinary temperatures upon moderate increases in pressure.
- **B.** at very large increases in pressure.
- **C.** because the molecules occupy a definite volume.
- **D.** because of the tendency of molecules to repel each other.
- **E.** because of Boyle's Law.

105. According to the gas laws,
(1.30)

- **A.** every gas, at constant pressure, expands to twice its former volume when the Centigrade temperature is doubled.
- **B.** gases, at constant temperature, diffuse with speeds directly proportional to the square roots of their densities.
- **C.** the volume of a gas is not changed if it is heated from 0°C. to 273°C., and at the same time the pressure is increased from 760 mm. to 1520 mm.
- **D.** if gases are mixed, the pressure of each lowers the pressure of the other.
- **E.** if the Law of Boyle is to hold, the gas must be kept at constant pressure.

106. (1.30) Deviations from the gas laws

A. are not explained by the kinetic-molecular theory.
B. appear only when gases are exposed to very high pressures.
C. indicate that the molecules themselves occupy no space.
D. result in gases being slightly more compressible under moderate increases than is in accordance with the Law of Boyle.
E. are present only in the conduct of the hypothetical perfect gas.

107. (1.30) Which of the following statements is *not* correct?

A. At constant temperature the pressure of a certain amount of gas increases with increasing volume.
B. At constant volume the pressure of a certain amount of gas increases with increasing temperature.
C. At constant pressure the volume of a certain amount of gas increases with increasing temperature.
D. In dealing with gas laws the most convenient scale of temperature to use is the absolute or Kelvin.
E. Equal numbers of molecules of all gases exert about the same pressure at a certain temperature and volume.

108. (1.30) Which of the following statements is *not* true?

A. Van der Waal's forces account for the fact that all substances can be liquefied.
B. The heat of vaporization results from the energy required to separate liquid molecules or atoms.
C. The heat of fusion results from the energy necessary to change a solid to a liquid.
D. Hydrogen gas probably has a larger heat of fusion than does water.
E. The macromolecular solid diamond would be expected to have a very large heat of fusion if it melts.

109. (1.30) The number of molecules in equal volumes of all gases under the same conditions of temperature and pressure are

A. widely different. **B.** equal. **C.** numerous.
D. comparatively few. **E.** unknown.

110. (1.30) According to theory, in a given mixture of oxygen and nitrogen, of uniform temperature throughout,

A. all the molecules are moving at the same speed.
B. all the molecules possess the same kinetic energy.
C. the average speed of the nitrogen molecules is the same as the average speed of the oxygen molecules.
D. the average kinetic energy of all the molecules in this mixture is the same as that of any other gas at the same temperature.
E. the average kinetic energy of all the molecules in this mixture is the same as that of any other gas at the same pressure.

111. (1.30) Select the true statement or statements.

1. If a gas expands against an external pressure, without absorbing heat from the environment, then the average kinetic energy of the gas molecules is increased.
2. If a gas is compressed, without losing heat to the environment, then the average kinetic energy of the gas molecules is unchanged.
3. If the volume of a gas remains constant while the gas absorbs a certain quantity of heat, then the average kinetic energy of the gas molecules is increased.

The correct selection includes only

A. 1. **B.** 2. **C.** 3. **D.** 1 and 2. **E.** 2 and 3.

112. (1.30) The law of PV = 845 T does not describe the behavior of concentrated solutions very closely. Which of the following best accounts for the deviation of concentrated solutions from this law?

A. The proportionality of number of solute molecules to solvent molecules is not the same in concentrated solutions as in dilute.
B. Molecules of solvent, being more numerous in concentrated solutions, interfere with the motion of solute molecules.
C. The concentration of solute molecules is greater in concentrated solutions.
D. Attraction between solute molecules is more effective in concentrated solutions.
E. Forces between solvent molecules become greater with decreasing distance between them.

113. (1.30) The van't Hoff coefficient *i* is introduced into the general law PV = 845 T in order to

A. correct for attraction between solute molecules.
B. include in the general law substances whose formulas do not adequately represent the separate particles in solution.
C. correct for the presence of solvent molecules, a condition not analogous to that in gases.
D. correct for deviations from the gas laws.
E. explain observed discrepancies between values calculated for gases and those calculated for solutions.

114. (1.30) The "additivity" of properties of dilute salt solutions can be regarded as direct evidence for the proposition that

A. in a dilute solution the solute consists only of ions.
B. in a dilute solution the solute is a mixture of elements.
C. Avogadro's law holds for all dilute solutions.
D. the activity coefficient of a dilute solution is proportional to its conductivity.
E. a great expenditure of energy is required to separate ions from one another.

115. (1.30) The theoretical basis of the calculation of *i* from the freezing point depression is provided by which of the following statements?

A. The freezing point depression for a 1 per cent solution is equal to 18.5°C.
B. The freezing point depression for a 1 per cent solution is equal to m x 18.5°C.
C. The freezing point depression for any solution containing 1 mol of solute per 100 gm of water is 18.5°C.
D. The osmotic pressure of a solution is equal to its freezing point depression; which is 18.5°C. for a solution containing 1 mol of non-electrolyte in 100 gm of water.
E. The osmotic pressure of a solution is equal to its freezing point depression divided by 18.5.

116. (2.00) Which of the following is the best statement of the reason for defining the term "pressure" as we do?

A. The expansive force of a gas is its most characteristic property.
B. The "elasticity" of a gas can be measured by observing the amount of force necessary to keep it confined in its volume.
C. A gas of a given kind (e.g., hydrogen), at a specified density and temperature, always exerts the same force against its containing walls regardless of the shape or volume of that container.
D. A gas of a given kind (e.g., hydrogen), at a specified density and temperature, exerts against a plane portion of its containing walls a force proportional to the area of that portion.
E. A term can be defined in any way one pleases, the only admissible question is whether the term as defined can be applied to anything.

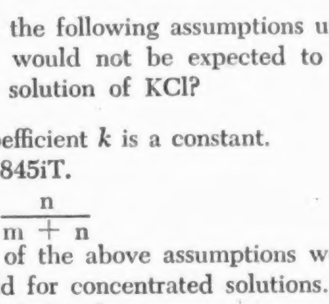
117. (2.00) Which of the following statements furnishes the strongest support for van't Hoff's extension of Avogadro's law to solutions?

A. The behavior of solute molecules may be expected to resemble that of gas molecules, since in both cases the distance between molecules is great relative to their size.
B. Densities of gases and concentrations of solutions are similar concepts, since both are expressible in terms of amount per unit volume.
C. Correct molecular weights can be found from the assumption that isotonic solutions contain the same weight of solute in equal volumes.
D. A gas pressure calculated for a given molecular concentration and temperature is found to correspond to an osmotic pressure measured under the same conditions.
E. Gas pressures and osmotic pressures vary in the same ratio with changes in temperature and concentration.

118. (2.00) Which of the following assumptions used in Arrhenius' argument would not be expected to hold for a concentrated solution of KCl?

A. the coefficient *k* is a constant.
B. $pv = 845iT$.
C. $a = \frac{n}{m + n}$
D. None of the above assumptions would be expected to hold for concentrated solutions.
E. Each of the above assumptions would be expected to hold for concentrated solutions.

119. (2.10) Two liquids, A and B, are introduced into two barometer tubes, the temperature of each being the same.



It is noticed (1) that in both cases a little of the liquid does not evaporate, and (2) that the mercury in the tube containing A is more depressed than that in the tube containing B. It follows from this that the vapor pressure of liquid A

A. is greater than that of liquid B.
B. is less than that of liquid B.
C. is the same as that of liquid B.
D. cannot be estimated relative to that of liquid B from the information given above.

120. (2.10) When the temperature and the volume are held constant, the pressure of a gas remains unchanged. Which one of the following principles is most closely associated with the explanation of this?

A. The addition of heat increases the speed of the molecules.
B. Molecules collide without loss of kinetic energy.
C. In an adiabatic change work is done at the expense of internal energy.
D. At a given temperature, the pressure exerted by a confined gas is proportional to the number of molecules it contains.
E. The volume coefficient of expansion for gases is a constant.

121. (2.10) The vapor collecting in the space above a liquid in a container is considered to saturate the space when

A. the density of the vapor equals the density of the liquid.
B. molecules leave and enter the liquid at equal rates.
C. no more molecules leave the liquid.
D. the liquid boils.
E. the vapor density is equal to 1.

122. (2.10) A certain mass of an ideal gas has 12,000 foot-pounds of random molecular kinetic energy at 400° Absolute temperature. What is the ***greatest possible*** amount of mechanical work (in foot-pounds) which the gas could perform when its temperature falls to 300° Absolute temperature?

A. 8000. **B.** 9000. **C.** 3000. **D.** 4000.
E. 12000.

For items 123 - 126 use the following key.

KEY

A. Diffusion. **B.** Immiscibility. **C.** Viscosity.
D. Compressibility. **E.** Surface Tension.

Select from the key the term that is *best* described in the items below.

123. (2.10) It is almost as if the water were covered with a thin, stretched sheet of rubber, which must be ruptured before the water can make contact with metal or glass.

124. (2.10) Observations suggest that the liquid moves by the sliding of one layer over the other.

125. (2.10) If a heavy gas, like carbon dioxide, is placed in the bottom of a container, and a light gas, such as hydrogen, is placed on top of the heavy gas, within a few hours the two will be completely mixed.

126. (2.10) Two liquids shaken together give a cloudy mixture with tiny globules of one liquid suspended in the other; when the shaking stops the globules coalesce, and the liquids separate into distinct layers.

127. (2.10) Changes in pressure have only a slight effect on reactions between solids. The best explanation of this is that

A. molecules of solids move very slowly.
B. solids are not appreciably reactive.
C. solids are not appreciably compressible.
D. in solids molecular freedom is limited.
E. none of the above is a satisfactory explanation.

128. (2.10) Assuming that the pressure remains constant in both cases, if a particular type of gas occupies 273 cc of space at 0°C., at a temperature of 10°C. it will occupy a space of

A. 263 cc. **B.** 273 cc. **C.** 283 cc. **D.** 278 cc.
E. 293 cc.

129. (2.10) If the volume and the absolute temperature of a certain mass of gas were both doubled, the pressure would be

A. one-half as great. **B.** twice as great.
C. one-fourth as great. **D.** four times as great.
E. unchanged.

130. (2.10) If the volume and absolute temperature of a given mass of gas were both reduced to one-half their former value, the pressure would be

A. one-half as great. **B.** one-fourth as great.
C. twice as great. **D.** four times as great.
E. unchanged.

131. (2.10) If the pressure is constant and a gas has a volume of 10 cubic feet at 20°C., its volume at 40°C. will be

A. 5 cubic feet. **B.** 20 cubic feet.
C. 10.7 cubic feet. **D.** 9.36 cubic feet.
E. none of these.

132. (2.10) If the temperature of a fixed volume of gas is 0°C., the temperature to which the gas must be raised to approximately double the pressure is

A. 2°C. **B.** 100°C. **C.** 273°C. **D.** 273°A.
E. none of these.

133. (2.10) If the volume and the absolute temperature of a given mass of gas under standard conditions were each tripled, the pressure would be

A. unchanged. **B.** three times as great.
C. six times as great. **D.** nine times as great.
E. changed by some quantity other than the above three.

134. (2.10) If the temperature of a gas is 0°C., the temperature to which the gas must be raised to approximately double the volume while maintaining the pressure constant is

A. 273°A. **B.** 273°C. **C.** 2°C. **D.** 100°C.
E. none of these.

135. (2.20) An effective way to increase the number of molecular collisions besides that of increasing the concentration is to

A. increase the velocity of the molecules.
B. increase the mass of the molecules.
C. reduce the temperature of the molecules.
D. increase the size of the molecules.
E. decrease the kinetic energy of the molecules.

136. (1.30) Which one of the following is true in the comparison of a liquid and a solid at the same temperature?

A. Liquid molecules have a greater degree of freedom.
B. Heat must be applied to make the molecules of a solid move.
C. Liquid molecules vibrate about a fixed position.
D. There is less space between the molecules of a liquid.
E. Liquid molecules are more dense.

137. (1.30) For a reaction to take place, it is necessary that

A. the particles be in the form of a gas.
B. the substance must be under a high pressure.
C. a force of attraction exist between the particles.
D. the particles collide.
E. the particles move at their maximum speed.

138. (1.30) Two substances which absorb heat when they react are heated until the reaction occurs at a fairly rapid rate. If the heat source is removed

A. the speed of the reaction will increase due to the increase in concentration.
B. the reaction will be explosive.
C. the speed of the reaction will decrease.
D. the speed of the reaction will remain unchanged.
E. the temperature will rise.

139. (2.10) A certain mass of gas has a volume of 200 cu cms under a barometric pressure of 76 cms of mercury. If this gas is subjected to an additional pressure of 4 cms of mercury, without changing its temperature, its volume will be approximately

A. 280 cu cms. **B.** 190 cu cms. **C.** 3800 cu cms.
D. 120 cu cms.

140. (2.10) A certain mineral has a density of 300 lbs/cu ft. The volume of a block of it which weighs 450 lbs is

A. 450 cu ft. **B.** 0.5 cu ft. **C.** ⅔ cu ft.
D. 1.5 cu ft. **E.** 4.5 cu ft.

Items 141 - 143. Van der Waal's equation states

$$(P + \frac{a}{V^2})\ (V - b) = RT.$$

141. (2.10) The term $(\frac{a}{V^2})$ represents

A. the volume occupied by the gas molecules.
B. the mean velocity of the gas molecules.
C. the attractive force between molecules.
D. the universal gas constant. **E.** none of these.

142. (2.10) The constant "b" represents

A. the volume occupied by the gas molecules.
B. the mean velocity of the gas molecules.
C. the attractive force between molecules.
D. the universal gas constant. **E.** none of these.

143. (2.10) The constant "R" represents

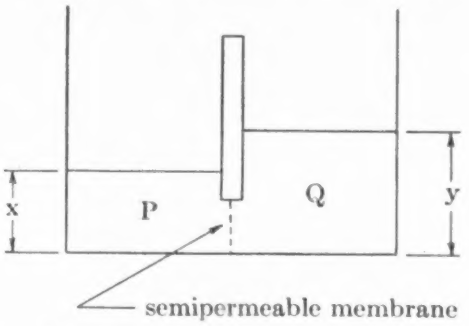
A. the volume occupied by the gas molecules.
B. the mean velocity of the gas molecules.
C. the attractive force between molecules.
D. the universal gas constant. **E.** none of these.

144. (1.10) A semipermeable membrane is one which

A. permits solvent molecules to pass in only one direction.
B. permits solute molecules to pass in only one direction.

C. permits solvent molecules to pass, but not solute molecules.
D. permits solute molecules to pass, but not solvent molecules.
E. exerts osmotic pressure on both solutions and gases.

Items 145 - 147. A glass vessel (see diagram) is divided into equal parts by a glass wall having a semipermeable membrane in its lower portion. Liquids P and Q assume the levels designated as *x* and *y*. Water is present in both compartments.



145. (2.10) From the diagram one may conclude most safely that

A. P must be pure water. **B.** Q must be pure water.
C. P must contain more solute particles than Q.
D. Q must contain more solute particles than P.
E. the number of grams of solute dissolved in P is less than that dissolved in Q.

146. (1.10) If one of the compartments is known to contain only pure water, then the osmotic pressure is determined by

A. the depth *x* of liquid P.
B. the depth *y* of liquid Q.
C. the difference in depths, y-x.
D. the ratio of depths, y/x.
E. the ratio of volumes of Q to P.

147. (3.00) Consider P and Q to be solutions of different substances, but containing the same weight of solute per unit volume. What may be concluded?

A. The molecular weight of the solute in P is greater than that in Q.
B. The molecular weight of the solute in Q is greater than that in P.
C. The solute particles in Q have a greater average mass than those in P.
D. The solute in P is ionized to a greater extent than that in Q.
E. The situation described is impossible; none of these conclusions may be made.

148. (1.30) In the case represented by the diagram, equilibrium is established between the solution in A and the water in B. Which of the following best accounts for the fact that the system arrives at such a state of equilibrium?

A. The osmotic pressure of the molecules inside vessel A and outside vessel A is the same.
B. Just as many molecules enter vessel A as leave vessel A in the same length of time.
C. The number of molecular impacts in unit time is the same on both inside and outside walls of the vessel A.
D. Under the increased pressure enough sugar molecules escape from vessel A to compensate for the increase in water molecules in vessel A.
E. The concentration of water molecules in vessel A has increased sufficiently to permit their rate of escape to equal the rate of entrance of water molecules.

149. (2.20) Van't Hoff would consider the osmotic pressure of the sugar solution in vessel A to be equal at the same temperature to the pressure of a gas in a vessel of unspecified volume provided

A. the concentration of gas molecules is equal to the concentration of sugar molecules.
B. the total number of gas molecules and sugar molecules is the same.
C. the number of mols of gas is equal to the number of mols of sugar.
D. the number of molecules per liter of gas is equal to the number of molecules per liter of water.
E. the concentration of the gas is equal to the total concentration of sugar and water.

150. (2.20) The reduction in pressure as a gas is cooled in a container of constant volume is best explained on the basis that the molecules

A. hit each wall of the vessel less often.
B. hit each wall of the vessel with less force.
C. hit each wall of the vessel with less force and less often.
D. contract. **E.** get closer together.

151. (2.20) Changes in pressure have only a slight effect on reactions between liquids. The best explanation of this is that

A. liquids are only slightly reactive.
B. in liquids, molecular freedom is limited.
C. liquids are not appreciably compressible.
D. liquid molecules move slowly.
E. liquids are not reactive.

152. (2.20) Changes in pressure have only a slight effect on reactions between solids. The best explanation of this is that

A. solid molecules move very slowly.
B. solids are not appreciably reactive.
C. solids are not appreciably compressible.
D. in solids, molecular freedom is limited.
E. none of the above is a satisfactory explanation.

153. (2.20) A student made a barometer by filling a long glass tube (closed at one end) with mercury, holding his finger over the open end and inverting the tube, then placing the open end in a dish of mercury and finally removing his finger. As a result, some of the mercury ran out of the tube but eventually the height of the mercury column was 75 cm. of mercury which checked rather closely with the laboratory barometer. Experimenting further he introduced a drop of water into the lower end of the tube and noted that the drop worked its way upward and after reaching the top, the barometer read 73 cm. of mercury. This relatively large decrease in the reading is explained as follows:

A. The weight of the water drop on top of the mercury caused the decrease.
B. The drop contained a lot of dissolved air which destroyed the vacuum.
C. The drop vaporized and exerted a vapor pressure.
D. Moisture in the air always increases a barometer reading.
E. The water formed a film on top of the mercury and prevented contact with the vacuum space.

154. Molecules of dye can move at the rate of 200 miles per (2.20) hour but they may actually require weeks to diffuse an inch up a tube of water. This phenomenon can be accounted for

A. because the dye molecules move upward slowly due to the pull of gravity.
B. because other molecules impede upward movement of the dye molecules by constantly changing the direction of their movements.
C. by more than one of the above.
D. by none of the above.

155. Molecular motions are maintained by no outside force, (2.20) yet continue indefinitely with no sign of diminishing speed. The reason that friction does not bring these tiny particles to rest, as it does other moving particles, is that

A. the molecules are too far apart for friction to have any effect.
B. the molecular speed and momentum are too great for the force of friction to have any effect.
C. friction between molecules would merely mean a transformation of one form of molecular energy into another form of molecular energy.
D. molecular motion is the result of more than one factor—several of which are not affected by friction.
E. More than one of the above are correct.

Items 156 - 159 refer to the following paragraph:

A gas is assumed to be mostly empty space, its isolated molecules moving helter-skelter like a swarm of angry bees in a closed room. Each molecule collides with others several billion times a second, changing its speed and direction at each collision, but uninfluenced by its neighbors between collisions. If a series of collisions brings it momentarily to a stop, new collisions will set it in motion; if its speed becomes greater than the average, successive collisions will slow it down. There is no order in the motion, no uniformity of speed or direction; we can say merely that the molecules maintain a certain average speed and that at any instant as many molecules are moving in one direction as in another.

156. According to the reading passage, it can be deduced (2.20) that the pressure exerted on the walls of a vessel by a contained gas arises from the

A. repulsion between molecules.
B. stored-up energy of the molecules.
C. kinetic energy of the molecules.
D. attraction of the walls for the gas molecules.
E. actions of more than one of these factors.

157. According to the reading passage, it can be deduced that (2.20) the reason gases can be easily compressed is because

A. of the wide distances between the molecules.
B. of the kinetic energy of the molecules.
C. the molecules are always in collision with each other.
D. there is no order in the motion of the molecules.
E. at any instant as many molecules are moving in one direction as in another.

158. According to the reading passage, it can be deduced that (2.20) the reason gases can be mixed readily with one another is because of the

A. lack of a particular order in the motion of their molecules.
B. kinetic energy of their molecules.
C. constant collisions between the molecules.
D. wide distances between the molecules.
E. results of more than one of the above.

159. According to the reading passage, molecular motion in (2.20) general never ceases because of the

A. complete absence of friction in molecular motion.
B. complete lack of molecular attraction between molecules.
C. wide distances between the molecules.
D. stored-up potential energy of the molecules.
E. effect of collisions between the molecules.

160. The apparently aimless, continuous movement of very (2.20) small particles which is known as the "Brownian Movement" is caused by

A. the influence of the earth's magnetic field.
B. the pull or attraction of the electron shell of the substance.
C. collision or jostling about by molecules.
D. the influence of an electric field.
E. repulsion between protons of the particles and the electrons of the surrounding media.

161. Boiling an egg in an open pan until it is hard cooked (1.10)

A. takes *less* time on a high mountain than at sea level.
B. takes *more* time on a high mountain than at sea level.
C. takes *the same* length of time on a high mountain as at sea level.

162. In the item preceding this, the best reason for the re-(2.20) sponse selected is that

A. the vapor pressure over boiling water is the same everywhere.
B. just as a car radiator boils more frequently and quickly on a mountain top so eggs will cook more quickly.
C. water boils at the same temperature everywhere.
D. an increased fuel supply required for boiling hastens the cooking time.
E. the temperature at which water boils is reduced with a reduction in atmospheric pressure.

163. When pumping air into an automobile tire, we notice (2.20) the wall of the pump becomes quite warm to the touch. This is because

A. the air being taken in is warmer than the air in the tire.
B. some of the mechanical energy of pumping is converted to heat.
C. the air molecules have increased their frictional drag.
D. warm air rushes back into the pump from the tire.

164. Water will keep cool in an unglazed earthenware jug (2.20) because

A. the jug absorbs cold air.
B. water vapor from the atmosphere condenses on the jug.
C. there is a large surface from which the water can evaporate.
D. the jug cools the water.
E. earthenware material is always cool.

165. When air from a compressed air tank expands, the air
(2.20) is reduced in temperature mainly because

A. convection takes place.
B. work is done at the expense of heat energy.
C. air is a good conductor of heat.
D. expansion increases the degree of molecular freedom.
E. the pressure of a gas is inversely proportional to the absolute temperature.

166. When air from a compressed air tank expands, the air
(2.20) is reduced in temperature because

A. convection permits rapid escape of heat.
B. work is done at the expense of heat energy.
C. air is a good conductor of heat.
D. expansion increases the degree of molecular freedom.
E. the pressure of a gas is inversely proportional to the absolute temperature.

167. The experimental observation that the volume of a gas
(2.20) may be greatly decreased by applying pressure is *best* explained by the assumption that

A. the average kinetic energy of gas molecules is directly proportional to the absolute temperature.
B. gas molecules collide without loss of kinetic energy.
C. gas molecules are small compared to the distance between them.
D. gas molecules exert almost no attraction on one another.
E. none of the above explains the assumption.

168. On the basis of the kinetic theory, gas pressure is ex-
(2.20) plained by the

A. change in momentum when the molecules collide with the walls of the container.
B. change in kinetic energy with changes in the temperature of the gas.
C. assumption that the molecules exert little or no attractive force on one another.
D. assumption that the molecules collide without loss in kinetic energy.
E. assumption that the distances between molecules are large compared to their diameters.

169. If the molecules in a tank of hydrogen have the same
(2.20) average speed as the heavier molecules in a tank of oxygen, we may be sure that

A. the pressure is the same in the two cases.
B. the hydrogen is at the higher temperature.
C. the hydrogen exerts the greater pressure.
D. the temperature is the same in the two cases.
E. the oxygen is at the higher temperature.

170. An alcohol rub cools the skin. This cooling effect
(2.20)

A. is an illusion arising from the effect of wetness.
B. occurs because the skin is too dry.
C. occurs because the alcohol is at a lower temperature.
D. is the result of rapid evaporation of the alcohol.
E. is the same for any liquid.

171. The reduction in pressure as a gas is cooled in a rigid
(2.20) container is best explained on the basis that the molecules

A. hit each wall of the vessel less often.
B. hit each wall of the vessel with less force.
C. hit each wall of the vessel both with less force and less often.
D. contract. **E.** get closer together.

172. Van't Hoff's coefficient *i* may be interpreted to represent
(2.20)

A. the average number of particles formed per molecule of solute due to association or dissociation.
B. the number of particles in excess of the normal number formed by dissociation.
C. the ratio of dissociated molecules to undissociated molecules.
D. the number of ions per mol of solute.
E. the excess osmotic pressure due to the ions present in solution.

173. What does van't Hoff mean by the term "ideal solu-
(2.20) tion"?

A. One which exhibits an increase in osmotic pressure with concentration.
B. One which has the same total molecular concentration as an equal volume of ideal gas under the same conditions.
C. One in which removal of the solvent forms an ideal gas consisting of the pure solute.
D. One in which solute molecules are far enough apart to act independently of one another.
E. One in which the solute is not dissociated.

174. According to Arrhenius, a solution of a substance which
(2.20) dissociates into ions would have, at a given temperature and percentage concentration,

A. a greater osmotic pressure than if the substance will not dissociate.
B. the same osmotic pressure as if the substance did not dissociate.
C. a smaller osmotic pressure than if the substance did not dissociate.
D. an osmotic pressure which may be greater or smaller than that of the undissociated solution, depending upon the value of the activity coefficient *a*.
E. an osmotic pressure which may be greater or smaller than that of the undissociated solution, depending upon the value of van't Hoff's coefficient *i*.

175. The opinion of Arrhenius given in your answer to item
(1.30) 174 is based most directly upon

A. the principle that the pressure of a system of gaseous or dissolved particles is affected by attractive forces between the particles, if such forces are of appreciable magnitude.
B. the principle that solutions of equal percentage concentration in the same solvent are isotonic.
C. the principle that the pressure of a system of gaseous or dissolved particles at a given temperature and concentration depends only on the number, not the size, of the particles.
D. the relation $a = \frac{n}{m + n}$.
E. the relation $pv = 845T$.

176. Which of the following is a consequence of the proposi-
(3.00) tions given in your answers to items 174 and 175?

A. At a given temperature, the total energy of the molecules of a solute is the same, regardless of the number of molecules which are "active."
B. At a given temperature, the total energy of the molecules of a solute is the less, the greater the number of "active" molecules.
C. At a given temperature, the average kinetic energy of translation of the molecules of a solute is the less, the greater the number of "active" molecules.

D. At a given temperature, the total kinetic energy of translation of the molecules of a solute is the same, regardless of the number of molecules which are "active."

E. At a given temperature, the total kinetic energy of translation of the molecules of a solute is the greater, the greater the number of molecules which are "active."

177. (2.30) Arrhenius assumes that the activity coefficient of an electrolyte approaches unity as the dilution approaches infinity. This implies

A. that a very dilute solution of an electrolyte contains one particle of solute for each molecule of solute, i.e., that practically all the molecules of the solute are undissociated.

B. that a very dilute solution of an electrolyte contains one ionized molecule of solute for every unionized molecule of solute, i.e., that about half the solute molecules are dissociated.

C. that a very dilute solution of an electrolyte consists almost entirely of ions.

D. that a very dilute solution of an electrolyte contains one dissociated molecule of solute for every molecule of solvent.

E. none of the above, since infinite dilution is an ideal state that can never really be approached by an actual solution.

178. (3.00) In the light of the propositions stated in your answers to items 176 and 177, one might expect the *dilution* of a fairly concentrated solution of an electrolyte to be accompanied by

A. a rise in the temperature of the solution.

B. a fall in the temperature of the solution.

C. no change in the temperature of the solution.

D. a temperature increase or decrease, depending upon the value of the activity coefficient a of the solute involved.

E. a temperature increase or decrease, depending upon the value of Arrhenius' coefficient k for the solute involved.

179. (2.30) If, in heating a particular type of gas, the volume is maintained at a constant value, then the net result will be

A. a fall in temperature of the contained gas.

B. inability of the gas to take on more heat.

C. a drop in the pressure of the contained gas.

D. an increase in the pressure of the contained gas.

E. none of the above.

180. (2.30) A decrease in the pressure on a given mass of gas is accompanied by

A. a gain of kinetic energy by the molecules of the gas.

B. a decrease in temperature.

C. more collisions between the gas molecules.

D. a decrease in volume.

E. more rapid movement of the molecules.

181. (2.30) A given amount of gas in a closed container is heated from room temperature to 100°F.; disregarding the possible expansion of the container, according to the kinetic theory

A. the gas has increased in weight.

B. the individual molecules of the gas have expanded.

C. the average distance between molecules has increased.

D. the average velocity of the molecules has increased.

E. the pressure on the sides of the container has decreased.

Items 182 - 188 involve certain theoretical principles. Select from the key the most closely related principle.

KEY

A. Atomic theory. **B.** Kinetic theory.
C. First Law of Thermodynamics.
D. Adiabatic change. **E.** Isothermal change.

182. (2.40) An increase in volume of a gas without adding heat from an external source.

183. (2.40) Atoms combine in simple ratios by weight.

184. (2.40) The heat from burning food could be transformed into mechanical energy.

185. (2.40) The ratio of the work in joules to the heat in calories is a constant.

186. (2.40) Molecules are perfectly elastic and rebound without energy loss after collision.

187. (2.40) The smallest particle of an element taking part in a reaction.

188. (2.40) A decrease in pressure of a gas with the addition of heat from an external source so that $PV = k$.

189. (2.40) From the generalization that "All gases at the same temperature have the same average molecular kinetic energy," it is possible to deduce that at the same temperature

A. heavy molecules should move more slowly than light molecules.

B. light molecules should move more slowly than heavy molecules.

C. light molecules move at the same speed as heavy molecules.

D. the relative speeds of light and heavy molecules have no relation to the molecular kinetic energies.

E. more than one of the above could be considered correct.

190. (2.40) Indicate the experimental or observational study giving best support for the statement "Molecules of a gas are in constant motion."

A. Winds exert pressure.

B. two gases interdiffuse quickly.

C. Warm air rises.

D. Heat is necessary to vaporize a substance.

E. Gases are highly compressible.

191. (3.00) A pure liquid and its vapor, maintained at a constant temperature, are contained in a tall cylinder fitted with a piston which exerts a pressure just equal to the vapor pressure of the liquid. If the pressure on the piston is doubled, the piston will

A. drop until the volume of the vapor is half its original volume.

B. not change its position.

C. drop until it touches the surface of the liquid, condensing all the vapor.

D. drop until the volume of the vapor and the volume of the liquid are each one-half of their original volumes.

E. none of the above.

192. (3.00) When the temperature of the air is increased from 20°C. to 30°C., the approximate increase in the average kinetic energy of the molecules according to the kinetic molecular theory would be

A. 3/100 percent. **B.** 3/10 percent. **C.** 3 percent.
D. 50 percent. **E.** 10 percent.

193. (1.30) The answer to the preceding item is in accordance with the statement that the average kinetic energy of molecules of a gas is

A. proportional to the temperature in degrees Centigrade.
B. proportional to the temperature in degrees Absolute.
C. inversely proportional to the temperature in degrees Centigrade.
D. inversely proportional to the temperature in degrees Absolute.
E. proportional to the square of the temperature in degrees Absolute.

194. (3.00) When the temperature of the air is increased from 20°C. to 30°C., the approximate increase in the average kinetic energy of the molecules according to the kinetic molecular theory would be

A. 0.34 percent. **B.** 3.4 percent. **C.** 10 percent.
D. 50 percent. **E.** none of these.

195. (3.00) Two gases, X and Y, at the same temperature are in containers of different sizes. The mass of an X molecule is greater than that of a Y molecule. It follows, therefore, that

A. Y molecules have a higher average speed than X molecules.
B. the average kinetic energy of X molecules is greater than that of Y molecules.
C. the pressure exerted by the gas in the smaller container is greater than the pressure of the other gas.
D. the molecules are closer together in the smaller container.
E. the information given does not warrant any of the above statements.

Items 196 - 197 refer to the following. A meteorologic balloon, inflated with helium when the air temperature is 20°C. and the barometric pressure is 1000 millibars, has a volume of 10 ft.^{3}

196. (3.00) If the air temperature should decrease to 0°C., the volume of the balloon would be

A. 10.7 ft.^{3} **B.** 10 ft.^{3} **C.** 9.3 ft.^{3} **D.** 0 ft.^{3}
E. some value appreciably different than any of the preceding choices.

197. (3.00) If the balloon should be allowed to rise until it reached a height of 10,000 feet, where the air temperature is 0°C. and the barometric pressure is 700 millibars, the volume of the balloon would be

A. 13.3 ft.^{3} **B.** 14.3 ft.^{3} **C.** 15.3 ft.^{3} **D.** 6.5 ft.^{3}
E. 7.0 ft.^{3}

198. (3.00) If both the volume and the absolute temperature of a gas under standard conditions were tripled, the pressure would be

A. unchanged. **B.** three times as great.
C. six times as great. **D.** nine times as great.
E. one-ninth as great.

199. (3.00) If the volume and the absolute temperature of a given mass of gas were both reduced to one-half their former value, the pressure exerted by the gas would be

A. one-half as great. **B.** one-fourth as great.
C. twice as great. **D.** four times as great.
E. unchanged.

200. (3.00) An unglazed pottery jug has walls that are porous. If such a jug were corked and placed in a room containing equal parts of several gases, after a reasonable time the jug would contain a mixture of the gases. The gas that would represent the greatest component of the mixture would be the one with the

A. lowest density. **B.** lowest temperature.
C. highest specific heat. **D.** highest molecular weight.
E. highest valence.

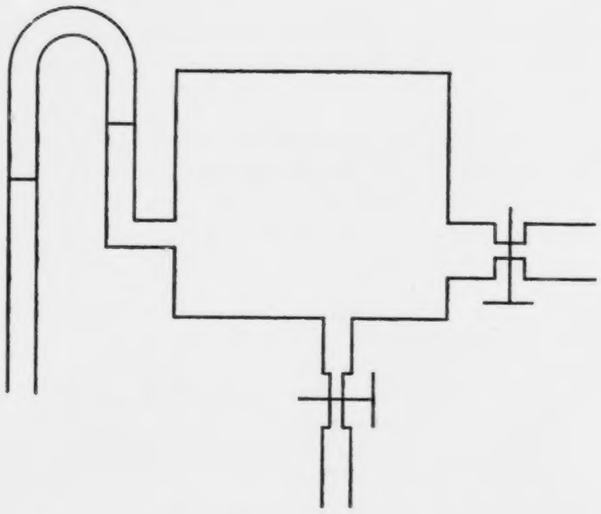
201. (3.00) To raise the temperature of 1 gm. of gas 1 degree C. would require

A. more heat if the gas were not allowed to expand on heating.
B. more heat if the gas were allowed to expand on heating.
C. the same amount of heat regardless of the above conditions of confinement.
D. The answer depends upon the kind of gas employed and thus cannot be answered with the above data.

202. (3.00) A paper bag is fully inflated with hydrogen and so weighted that it will float half way between the floor and ceiling of a high auditorium of still air. If the average air temperature of the auditorium is raised 10 degrees F., the bag will

A. float lower. **B.** float higher.
C. remain at the same height.
D. the bag cannot be made to float half way to the ceiling. It will either rise all of the way or not rise at all.

Item 203 refers to the following diagram.



203. (3.00) The gas in the above apparatus is under pressure of several inches of mercury as indicated by the mercury in the right side of the U tube. The whole apparatus at the start of the experiment is at room temperature. A stopcock is suddenly opened and the gas brought to room pressure. The mercury on the two sides of the U tube will then be at the same level. The stopcock is again closed. On standing (room temperature remaining constant)

A. the mercury on the right side of the U tube will rise.
B. the mercury on the left side of the U tube will rise.
C. the mercury in the U tube will not change in level.
D. the data on hand is insufficient to answer the question.

For Items 204 - 207 choose from the key list the information that would be *most* helpful in explaining the following situations.

KEY

A. At constant temperature the volume of a gas varies inversely as the amount of pressure applied.
B. At constant pressure the volume of gas is proportional to the absolute temperature.
C. If the volume of a gas is held constant the pressure exerted by a gas is proportional to the absolute temperature.
D. The pressure exerted by a gas is the same whether other gases are present or not, provided there is no chemical action between the different gases.
E. Equal volumes of gases under similar conditions of pressure and temperature contain equal numbers of molecules.

204. (3.00) The speed of jet-propelled aircraft is controlled by the rate at which fuel is burned.

205. (3.00) A football properly inflated on a cold day in the locker room may be improperly inflated a short time after being in play.

206. (3.00) An air-filled test tube with wet iron filings lining the inside was inverted over water. After a time water had risen ⅕ of the way up the tube even though there had been no changes in room temperature or pressure.

207. (3.00) Organs associated with the human ear register discomfort when a person ascends or descends rapidly in an elevator.

Items 208 - 209 deleted.

210. (1.30) Evaporation from a liquid results in

A. a decrease in the average speed of the molecules of the liquid.
B. an increase in the temperature of the liquid.
C. an increase in the rate of collision between molecules of the liquid.
D. an increase in the average speed of the molecules of the liquid
E. a decrease in the amount of vapor above the liquid.

211. (3.00) To triple the volume of a given weight of gas at 27°C., keeping pressure constant, raise the temperature to

A. 81°C. **B.** 273°C. **C.** 900° Absolute.
D. 627° Absolute. **E.** 546° Absolute.

212. (3.00) Two identical leak-proof balloons A and B are filled, 1 with hydrogen and 2 with helium, so that at room temperature and pressure their volumes are equal. When they are taken together to the top of a mountain

A. 1 will become appreciably bigger than 2.
B. 2 will become appreciably bigger than 1.
C. 1 and 2 will have approximately equal volumes.

213. (3.00) A mass of a perfect gas is compressed by a piston from 10 cu. ft. to 5 cu. ft., and simultaneously cooled from 273°C. to 0°C. As a consequence there is

A. an increase in pressure. **B.** a decrease in pressure.
C. a decrease in density.
D. no change in pressure or density.
E. an increase in density.

214. (3.00) To halve the pressure on a given mass of gas at 27°C., keeping its volume constant, change the temperature to

A. 54°C. **B.** 150° Absolute. **C.** 13.5°C.
D. 600° Absolute. **E.** −27°C.

215. (3.00) The mean velocity of an oxygen molecule at 0°C. is 460 meters/sec. If the molecular weight of oxygen is 32 and the molecular weight of helium is 4, then the mean speed of a helium molecule at 0°C. is

A. 230 m/sec. **B.** 326 m/sec. **C.** 650 m/sec.
D. 920 m/sec. **E.** 1300 m/sec.

216. (3.00) One liter of a gas has a pressure of 1 atmosphere at 0°C. What will be the volume of the same quantity of gas at 570 mm pressure and 27°C.?

A. 1.47 liters. **B.** 1.21 liters. **C.** 1 liter.
D. 0.68 liters. **E.** 0.825 liters.

217. (3.00) A gas in a 200 cubic centimeter container has a pressure of 60 mm of mercury at 27°C. If the temperature is raised to 127°C. and the container expands to 250 cubic centimeters what will be the pressure of the gas?

A. 64 mm mercury. **B.** 100 mm mercury.
C. 36 mm mercury. **D.** 56 mm mercury.
E. 226 mm mercury.

218. (3.00) If we had a substance made up of atoms which had no attraction for one another, which of the following would be most nearly correct?

A. Ten million atoms of this substance as a gas would occupy a much larger volume than 10 million molecules of the gas O_2, at the same temperature and pressure.
B. This substance would be a gas which could not be liquefied or changed to a solid.
C. This substance could never exist as a gas at all but would be a solid or a liquid.
D. If this substance were contained in a stoppered bottle and the temperature were increased, the pressure the substance exerts on the sides of the bottle would decrease.
E. As a gas it would behave like any other gas since all gases are of this type.

219. (3.00) One liter each of four gases, W, X, Y, and Z, at standard conditions are passed into a one-liter container, where they combine to form a new gas (compound Q). The pressure of gas Q is found to be one atmosphere at 0°C. What conclusions may be drawn?

A. The number of molecules of Q formed is greater than the number of molecules in any one of the reactants.
B. The number of molecules of Q formed equals the total number of molecules of all the reactants.
C. The number of molecules of Q formed is less than the number of molecules in any one of the reactants.
D. The number of molecules of Q formed equals the number of molecules in any one of the reactants.
E. 6 x 10^{23} molecules of Q were formed.

220. (3.00) A liter of hydrogen gas at 0°C. and a pressure of one atmosphere weighs 0.09 gram. If hydrogen is placed in a rigid container and the temperature is raised from 0°C. to 273°C., the weight of the liter of gas will

A. become 1/273 as great.
B. be reduced by one-half. **C.** remain the same.
D. become twice as great.
E. become 273 times as great.

221. (3.00) The pressure of the gas on the walls of the container will

A. become 1/273 as great.
B. be reduced by one-half. **C.** remain the same.
D. become twice as great.
E. become 273 times as great.

222. (3.00) In the manufacture of ammonia, hydrogen is combined with nitrogen. All substances are gaseous. The following equilibrium is known to exist:

$$3H_2 + N_2 \rightleftarrows 2NH_3 + \text{heat}.$$

Starting from a system in equilibrium an increase in pressure

A. will favor production of NH_3.
B. will favor decomposition of NH_3
C. will have no effect upon production of NH_3.

223. (1.30) The reason for the effect observed in item 222 is

A. gases decompose under high pressure.
B. increase in pressure raises temperature.
C. increase in pressure favors the formation of fewer molecules.
D. high pressure always makes gases combine.

Items 224 - 225. An automobile tire is pumped up to a total pressure of 40 pounds per square inch at a temperature of 20°F.

224. (3.00) Assuming the volume of the tire does not change, what is the total pressure in the tire in pounds per square inch if the temperature of the tire is changed to 140°F.?

A. 46. **B.** 35. **C.** 50. **D.** 65. **E.** 280.

225. (3.00) A tire gauge placed on the tire when the temperature is 140°F. would read, in pounds per square inch,

A 31. **B.** 35. **C.** 50. **D.** 65. **E.** 280.

226. (3.00) A certain mass of gas is confined in a cylinder and occupies a volume of 5 cubic feet when the Absolute temperature (F degrees) is 1000°. If the applied pressure on the piston is kept constant and the Absolute temperature of the gas is lowered to 800° (F degrees), the volume occupied by the gas is, in cubic feet,

A. 1. **B.** 2. **C.** 4.3. **D.** 4. **E.** 6.2.

227. (3.00) The density of oxygen at 273°C and a pressure of 2 atmospheres is

A. 0.0002 gm/cm³. **B.** 0.0007 gm/cm³.
C. 0.0014 gm/cm³. **D.** 0.0056 gm/cm³.
E. 0.0098 gm/cm³.

Item 228 deleted.

229. (3.00) A certain specimen of gas has a volume of 1.5 liters, at 0°C. and atmospheric pressure. At 0°C. and a pressure of 3 atmospheres, this specimen of gas will occupy a volume of

A. 0.5 liter. **B.** 1.0 liter. **C.** 1.5 liters.
D. 3.0 liters. **E.** 4.5 liters.

230. (3.00) The same specimen of gas, at 273°C. (= 546° Absolute) and a pressure of 3 atmospheres, will occupy a volume of

A. 0.5 liter. **B.** 1.0 liter. **C.** 1.5 liters.
D. 3.0 liters. **E.** 4.5 liters.

Items 231 - 237. Lavoisier proposed the hypothesis that the liquid state occurs when the internal attractive forces of the particles of a body no longer act in any appreciable degree, and that such a body is confined to a definite volume by the pressure of the atmosphere.

Mark each of the following propositions

A. if it is a consequence of Lavoisier's views, and is accepted by kinetic-molecular theory.
B. if it is a consequence of Lavoisier's views, and is rejected by kinetic-molecular theory.
C. if it is contrary to Lavoisier's views, and is true according to kinetic-molecular theory.
D. if it is contrary both to Lavoisier's views, and to kinetic-molecular theory.

231. (3.00) A free liquid surface cannot exist without molecules of some substance in the gaseous state above it.

232. (3.00) A free liquid surface cannot exist without molecules of vapor of the same substance as the liquid above it.

233. (3.00) If a liquid surface is suddenly exposed in a vacuum, then the molecules which escape from the liquid to form vapor do not undergo an increase in their potential energy.

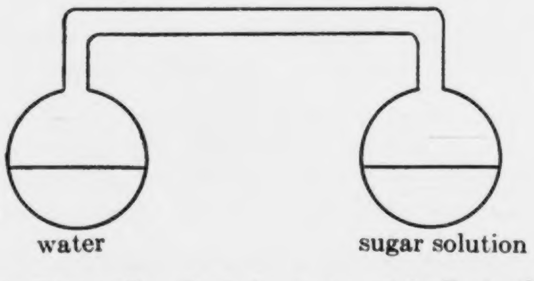
234. (3.00) Any liquid will boil if a sufficiently low pressure is maintained above it.

235. (3.00) At any given temperature, a liquid may be prevented from boiling by the introduction of dry oxygen gas at sufficiently high pressure over the surface of the liquid.

236. (3.00) A small quantity of water in a large container maintained at 20°C. may be prevented from evaporating by the introduction of dry oxygen gas at sufficiently high pressure over the surface of the water.

237. (3.00) If it were possible to remove all the air from the space above the mercury column in a barometer, the barometer could not function since, if there were no air above it, all the mercury in the barometer tube would evaporate.

238. (3.00) Two glass flasks, one containing a solution of sugar in water and the other pure water, are connected by means of a glass tube. Which of the following results is most likely?



A. Eventually all of the water originally in the right-hand flask will pass into the sugar solution by evaporation and subsequent condensation.
B. Eventually all of the water originally in the sugar solution will pass into the right-hand flask by evaporation and subsequent condensation.

C. Eventually the concentration of sugar in the two flasks will become equal as a result of evaporation and subsequent condensation.
D. Eventually all of the water will evaporate from both flasks.
E. After all of the water in the right-hand flask has evaporated and most of it has condensed in the sugar solution, equilibrium will be established.

239. (1.30) The principle most closely underlying your answer in the preceding item is that

A. the osmotic pressure of a solution is higher than that of the pure solvent.
B. the vapor pressure of a solvent is reduced by the presence of dissolved material.
C. the osmotic pressure of a solvent is reduced by the presence of dissolved material.
D. the vapor pressure of a solution is the sum of the vapor pressures of solute and solvent.
E. isotonic solutions have the same vapor pressure.

240. (3.00) When one mol of a certain gas is dissolved in 1000 grams of water, the observed freezing point of the resulting solution is observed to be $-3.5°C$. The value of i for this solute is

A. 1. B. 1.9. C. 2. D. 3.5.
E. not calculable unless the molecular weight of the gas is known.

241. (2.20) On the basis of the data above, one may conclude that the gas in solution is

A. almost completely dissociated.
B. dissociated, but to an unknown extent.
C. ionized and dissociated.
D. neither ionized nor dissociated.
E. composed of molecular complexes and not ionized.

242. (3.00) A solution consisting of one gram of an organic solute in 100 grams of water is observed to freeze at $-0.20°C$. The molecular weight of the solute is, therefore, nearest

A. 10. B. 60. C. 90. D. 100. E. 120.

243. (3.00) Arrhenius refers to "objections" to his theory "which may probably be urged from the chemical side." Which of the following could be an objection of this sort?

A. There is no reason to believe that the osmotic pressures of solutions at the same temperature and with the same number of particles are necessarily equal.
B. Arrhenius' theory carries the implication that an electric current can cause chemical changes.
C. Solutions of electrolytes do not possess an electric charge.
D. The chemical properties of a solution of an electrolyte are not the properties of its constituents; e.g., a solution of sodium chloride does not have the properties of sodium or of chlorine.
E. When substances dissociate or decompose chemically (as in the reaction: $NH_4Cl \rightarrow NH_3 + HCl$) the result is an increase in pressure.

244. (4.10) Experimental evidence that a gas consists mostly of empty space is the fact that

A. the density of a gas becomes greater when it is liquefied.
B. gases exert pressure on the walls of their containers.
C. gases are transparent.
D. heating a gas increases molecular motion.

Items 245 - 251 refer to the kinetic-molecular theory. After each item number on the answer sheet, blacken space

A. if the item refers to observational or experimental evidence which supports the theory.
B. if the item refers to an hypothesis or an assumption concerning the theory which was formulated long before there was experimental evidence to test it, or has not as yet been entirely proven to be true experimentally.
C. if the item refers to something which has nothing to do with the theory.

245. (4.10) The volume of a gas increases with an increase in temperature when the pressure remains constant.

246. (4.10) A gas always exerts pressure no matter how much it expands.

247. (4.10) Most gases are colorless.

248. (4.10) Gases are composed of small particles called molecules which are relatively far apart and in rapid motion.

249. (4.10) Gases diffuse readily.

250. (4.10) Molecules are perfectly elastic.

251. (4.10) Molecules on colliding lose no energy.

252. (4.20) The weight of a molecule of oxygen is 16 times as much as the weight of a molecule of hydrogen. One balloon is to be inflated with two liters of oxygen and another balloon of the same size with two liters of hydrogen, both gases to be measured under the same conditions. If both are kept at the same temperature, the pressure of the oxygen in the first balloon necessary to attain the same volume as the second balloon will be

A. sixteen times as great as in the second.
B. one-sixteenth as great as in the second.
C. equal to that in the second.
D. four times as great as in the second.
E. one-fourth as great as in the second.

253. (4.20) If the temperature of a confined gas were kept constant, then

A. the volume would increase as the pressure increased.
B. the pressure would decrease as the volume increased.
C. the volume and the pressure would be directly proportional.
D. the volume would decrease as the pressure increased.
E. more than one of the above are correct.

254. (4.20) If a centigrade thermometer is inserted in a vessel containing a gas, and if work is done on the gas (by compression or friction), the thermometer indicates a rise in temperature. All conclusions from this experiment are correct except that

A. the work done on the gas serves to increase the kinetic energy of the gas molecules.
B. the coefficient of expansion of glass is low, hence only the mercury will be affected.
C. stronger collisions of the molecules occur within the mercury-containing glass bulb.

D. some energy due to the increased velocity of the gas molecules is transferred to the mercury molecules.

E. an expansion of the mercury column occurs as the increased agitation of mercury molecules results in their greater separation.

255. (4.20) A glowing splint placed in oxygen will burst into flame. Assume that if placed in other gases lacking in oxygen, the glowing splint is extinguished. A jar of oxygen and a jar of nitrogen were placed with their mouths separated by a glass plate. The plate was removed for a few seconds, then a glowing splint was placed in each jar. The splint burst into flame in both containers. This provides *direct evidence* that

A. the two gases intermingled.
B. the oxygen diffused into the nitrogen.
C. the nitrogen diffused into the oxygen.
D. oxygen is present in both jars.
E. none of the above is correct.

Items 256 - 261 are to be answered after reading the article by Linus Pauling and in reference to the key.

Every atom consists of one nucleus and one or more electrons. The nucleus is a small, heavy particle containing almost all the mass of the atom. It has a positive electrical charge equal in magnitude to the charge of one electron, or to an integral multiple of this charge. The electric charge of nuclei is positive, and that of electrons is negative. Ordinary matter is electrically neutral; that is, it contains equal amounts of positive and negative electrical charge.

A phase is a homogeneous part of a system, separated from other parts by physical boundaries. For example, if a flask is partially full of water in which ice is floating, the system comprising the contents of the flask consists of three phases, the solid phase, ice, the liquid phase, water, and the gaseous phase, air.

The separation of two different phases is often rather easy. Particles of a solid phase mixed with a liquid phase may be separated from the liquid by filtration. Often the solid is present because it has been produced from solution in the liquid by a chemical reaction or by change in conditions (such as by cooling); the solid is then called the precipitate.

The rate at which molecules evaporate from a crystal surface is proportional to the area of the surface, but is essentially independent of the pressure of the surrounding gas, whereas the rate at which gas molecules strike the surface and stick to it is proportional to both the surface area of the crystal and the number of gas molecules per unit volume pressing against or in contact with that surface area. Hence, the process of evaporation will continue to increase the density (and pressure) of the gas until it is built up to the point where the rate of condensation becomes equal to the rate of evaporation. The pressure of gas at which this equilibrium exists is called the vapor pressure of the crystal at the given temperature.—Linus Pauling.

KEY

A. The statement is true and the reason stated supports the truth of it.
B. The statement is true but the reason does *not* support the truth of it.
C. The statement is false.

256. (4.20) A positive charge has no attraction for a negative charge in the atom *because* the ordinary atom is electrically neutral.

257. (4.20) The nucleus of an atom contains only one positive charge but may have more than one electron *because* it takes more than one negative charge to balance a large positive charge.

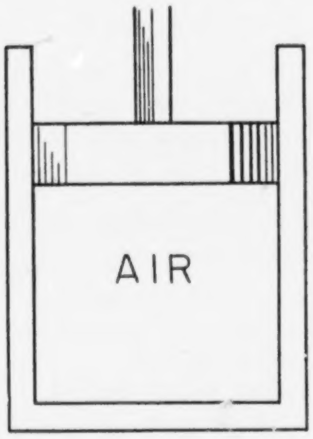
258. (4.20) The molecular activity of water in the gaseous phase is greater than that of water in the liquid phase *because* water in the gaseous phase contains more heat energy.

259. (4.20) When the process of evaporation continues until the rate of condensation equals the rate of evaporation, evaporation ceases *because* equilibrium has been reached.

260. (4.20) Crystals may separate out of certain solutions when they are cooled *because* cooling makes a chemical reaction take place.

261. (4.20) Particles of a solid phase mixed with a liquid phase frequently may be separated rather easily *because* filtration can be employed.

Items 262 - 268 refer to the following diagram.



A piston is pushed down in a cylinder of air as shown in the diagram. After each item number on the answer sheet, blacken space

A. if the statement is true and the reason given is true.
B. if the statement is true, but the reason given is false.
C. if the statement is itself false.

262. (4.20) The gas heats up, because the average kinetic energy of the molecule has been increased.

263. (4.20) The number of molecules is increased, because the gas heats up.

264. (4.20) The gas heats up, because energy is expended in pushing down on the piston.

265. (4.20) The molecules slow down, because they are being pushed together.

266. (4.20) The cylinder cools off, because the molecules absorb heat from it.

267. (4.20) The pressure increases, because the air molecules collide more frequently with the walls of the cylinder.

268. (4.20) The temperature of the gas increases, because the air molecules lose energy as they collide with each other.

Items 269 - 270 refer to the gas laws. Kinetic theory satisfactorily explains the behavior of a perfect gas so that Boyle's Law, PV = C, holds true. However, many gases are not perfect and Van der Waal proposed two corrections: First, he argued that the pressure in an actual gas would be less than the pressure in a perfect gas.

269. (4.20) Which one of the assumptions in the kinetic theory of gases would best support Van der Waal in stating that actual gases exert less pressure than a perfect gas?

- **A.** Molecules are very far apart as compared to their size.
- **B.** Molecules collide without loss of kinetic energy.
- **C.** Molecules exert practically no attractive forces on each other.
- **D.** The absolute temperature of a gas is proportional to the kinetic energy of its molecules.

270. (4.20) Second, Van der Waal proposed that V in the formula should be V — b where b represented a small volume. The best support for making this change in the formula follows from the statement that

- **A.** the volume of a gas increases with an increase in temperature.
- **B.** molecules themselves take up some space.
- **C.** molecules are in constant motion.
- **D.** molecules have weight which although small cannot be neglected.
- **E.** gases are elastic.

Essay Question

271. (5.00) Among the problems which, in the course of history, have engaged the attention of scientists, a certain set can be classed under the general head, "The structure of matter." Investigations of problems of this sort have been concerned with questions about the *kinds of parts* of which matter is composed, and the *laws governing the "behavior,"* or the "inter-actions," of those parts.

A second set of scientific investigations has been concerned with various aspects of the general question, "How do bodies move, and how do they affect one another's motions?"

Show how, in the investigations of van't Hoff and Arrhenius, the results of investigations of the second kind have been of use in treating problems of the first kind. Your discussion should include:

1. a clear statement of the general principles concerning the motions of bodies which are used in these investigations;
2. an analysis of the assumptions concerning the parts of matter involved in the application of the principles of motion to the problem at hand;
3. an analysis of the justification for those assumptions;
4. an indication of the solution to the problem and of how that solution is reached.

(This list is not intended to serve as an outline for your essay.)

Your essay will be graded on the basis of your understanding of the problem posed for you, as indicated by your success in organizing the essay so that it is *relevant* to that problem; your understanding of the content of the investigations you discuss; and the accuracy of your analysis of the principles and assumptions employed in those investigations.

One hour is allowed for this section of the examination.

For items 272 - 286 *read the following selection carefully.*

At a temperature of 0° Centrigrade and standard barometric pressure there are about 27,000,000,000,000,000,000 molecules in one cubic centimeter of air. These molecules are in constant motion, and have an average velocity of about one-quarter of a mile per second. This is slightly more than the speed of sound. Under these conditions the average distance travelled by a molecule before it strikes another is eight millionths of a centimeter.

In interstellar space a molecule is believed to travel about 50 billion miles before it collides with another on the average of about once a year.

Directions: For items 285 - 289 select the best answer and mark the corresponding space on the answer sheet to the right of the item number.

272. (6.20) The statements in the above selection are

- **A.** wild guesses.
- **B.** true, because they are based on statements in a reliable textbook.
- **C.** incredible, because no one can even see molecules, much less measure their speeds and numbers of collisions.
- **D.** probably close to the truth, because they are the results of calculations based on a well-established theory.
- **E.** incredible, because no one has ever been able to travel to interstellar space.

273. (1.24) The statements in the above selection are

- **A.** observed facts.
- **B.** generalized presentation of facts. **C.** hypotheses.
- **D.** reasoning based on a theory.
- **E.** experimental data upholding or disproving an hypothesis.

274. (1.25) The statements in the second paragraph of the above selection are obtained by the process of

- **A.** experimentation. **B.** generalization.
- **C.** observation.
- **D.** reasoning from specific data to a principle.
- **E.** applying general principles to a specific case.

275. (1.25) The statements in the selection probably are

- **A.** impossible to check because one cannot see or handle individual molecules.
- **B.** impossible to check because no instruments are available to measure such distances or speeds.
- **C.** possible to check experimentally by direct methods.
- **D.** impossible to check because of the very large and very small numbers involved.
- **E.** possible to check experimentally by indirect methods.

276. (4.20) If the statements in the selection are true, which one of the following is inconsistent with them?

- **A.** Matter must be evenly distributed in interstellar space.
- **B.** Man can build a machine which will travel as fast as an average air molecule.
- **C.** Probably in air few molecules travel as far as one centimeter before colliding with others.
- **D.** In interstellar space, molecules travel an average distance of 50,000,000,000 miles before changing direction.
- **E.** Interstellar space is a complete vacuum.

16. Atomic-Molecular Theory; Electron Theory of the Atom

ATOMIC-MOLECULAR THEORY;
ELECTRON THEORY OF THE ATOM

Items 1 - 10. Write the words in the gaps necessary to complete the following statements:

1. (1.10) The smallest particle in any atom is called the________.

2. (1.10) The electron is a________charged particle of electricity.

3. (1.10) The nucleus of an atom is in part made up of________.

4. (1.10) The element with the lightest atom is________.

5. (1.10) The element with the heaviest atom is________.

6. (1.10) The atomic number of an element is determined by the number of________in its nucleus.

7. (1.10) The mass number of an element is the number of ________plus the number of________in its nucleus.

8. (1.10) One type of atom smasher is called the________.

9. (1.10) The________of an element cannot be separated by chemical methods.

10. (1.10) The mass number of an element minus the atomic number gives the number of________in the nucleus.

11. (1.10) Iron reacts with sulfur as given by the equation, $Fe + S \rightarrow FeS$. The approximate atomic weight of iron 56, sulfur 32. The number of grams of FeS obtained from 100 gm. of S is approximately

A. 57. **B.** 175. **C.** 275. **D.** 157. **E.** 36.

Items 12 - 14 refer to the "building blocks" of matter. For each item select from the key the correct response.

KEY

A. Molecule. **B.** Neutron. **C.** Atom.
D. Electron. **E.** Proton.

12. (1.10) A particle which accounts for some elements having several atomic weights.

13. (1.10) The smallest particle of a pure substance that can exist and retain all its properties.

14. (1.10) The charged particle found only in the nucleus.

15. (1.10) Which one of these is an inert gas?

A. Ammonia. **B.** Carbon monoxide.
C. Sulphur dioxide. **D.** Hydrogen. **E.** Helium.

16. (1.10) Basically the atom is generally conceived as

A. a solid spherical mass which is neutral in charge.
B. a nucleus and electrons all traveling in the same plane but at various energy levels.
C. paired groups of electrons and protons, widely but uniformly distributed.
D. a nucleus of protons and generally neutrons with as many electrons as protons traveling in orbits around the nucleus.
E. having an atomic weight equal to the weight of the neutrons and the electrons.

17. (1.10) It is generally supposed that the atom is

A. a solid but elastic sphere.
B. a positively charged nucleus and one or more planetary electrons.
C. a negatively charged nucleus and one or more planetary protons.
D. an equal number of positrons and electrons distributed in pairs.
E. a negatively charged nucleus and an equal amount of positive charge distributed around it.

18. (1.10) During chemical combinations metallic atoms always

A. become larger. **B.** gain electrons.
C. lose electrons. **D.** lose kinetic energy.
E. gain kinetic energy.

19. (1.10) Helium contains 2 electrons in its outer ring. The other inert gases are inert because they

A. need 2 electrons in the outer ring.
B. have 2 electrons in the outer ring.
C. have 8 electrons in the outer ring.
D. have 6 electrons in the outer ring.
E. have lower atomic weights than the other elements.

20. (1.10) The most active non-metal is

A. oxygen. **B.** chlorine. **D.** manganese.
D. fluorine. **E.** iodine.

21. (1.10) A substance composed of only one kind of atoms is

A. a colloid. **B.** a solvent. **C.** an element.
D. a compound. **E.** a solution.

22. (1.10) The smallest particle of any chemical element that can exist by itself and retain the qualities that distinguish it as an element is the

A. electron. **B.** proton. **C.** neutron. **D.** atom.
E. molecule.

23. (1.10) The inert gas most used in signs made of glass tubing is

A. helium. **B.** xenon. **C.** neon. **D.** krypton.

24. (1.10) In 1911 Rutherford bombarded gold foil with alpha particles. This experiment helped to establish the electron theory by showing

A. the mass of the atom.
B. that the atom is mostly empty space and the plus charge is concentrated.
C. the number of protons present in the nucleus.
D. the charge of an electron.
E. the presence of charged particles derived from atoms.

Items 25 - 28 are concerned with the men or experiments which helped to establish the electron theory of matter. For each item select from the key the most closely related idea.

KEY

A. The mass of the atom.
B. That the atom is mostly empty space and the plus charges concentrated.
C. Measure of the number of protons present in the nucleus.
D. Revealed the presence of charged particles derived from atoms.
E. None of these.

25. Rutherford bombarded gold foil with alpha particles
(1.10) in 1911.

26. Moseley's experiments of 1914.
(1.10)

27. Aston's spectrograph.
(1.10)

28. Millikan's oil drop experiment.
(1.10)

For items 29 - 34, select from the key the idea most closely related to that expressed by each item.

KEY

A. Valence. **B.** Radical. **C.** Compound formation.
D. Formula of a compound. **E.** None of these.

29. The number of electrons lent, borrowed, or shared.
(1.10)

30. Certain atoms within a molecule are held together by
(1.10) sharing electrons and behave as a unit.

31. The number of electrons lent must equal the number
(1.10) borrowed.

32. A combination of two atoms of an element.
(1.10)

33. The total plus valence must equal the total negative
(1.10) valence.

34. A charged atom.
(1.10)

35. The valence of the metal in $CaSO_4 \cdot 2\ H_2O$ is
(1.10)

A. One. **B.** Two **C.** Three. **D.** Four. **E.** Six.

36. Which one of these is correct concerning the neutron?
(1.10)

A. The atomic weight of an atom equals the sum of the weights of the protons and the neutrons.
B. Every element contains one or more neutrons.
C. The neutron prevents the attractive forces of the protons and electrons from causing them to come together.
D. The neutron like the electron is of negligible weight relative to the total weight of the atom.
E. The atomic number equals the number of neutrons present in the atom.

37. In general, the atomic weight of an element is equal to
(1.10)

A. the sum of the weights of the protons and neutrons in the nucleus.
B. twice the atomic number.
C. the molecular weight in grams.
D. the sum of the protons and the planetary electrons.
E. the sum of the neutrons and the valence electrons.

38. All of these gases are alike in a certain respect except
(1.10)

A. Hydrogen. **B.** Helium. **C.** Neon. **D.** Argon.
E. Krypton.

39. A group of atoms within a molecule which are held
(1.10) together by sharing electrons and which behave as a unit during chemical reaction is termed

A. a compound. **B.** a mixture. **C.** a salt.
D. an alloy. **E.** a radical.

Items 40 - 46 are chemical symbols. Select from the key the proper valence for each item.

KEY

A. +1. **B.** +2. **C.** −1. **D.** −2. **E.** −3.

40. O. (1.10) **41.** Ca. (1.10) **42.** Zn. (1.10)

43. Ag. (1.10) **44.** K. (1.10) **45.** H. (1.10) **46.** SO_4. (1.10)

Items 47 - 52 involve the valence of elements or radicals. For each item select the most closely related description.

KEY

A. Acquires or has a positive valence of 1.
B. Acquires or has a negative valence of 1.
C. Acquires or has a positive valence of 2.
D. Acquires or has a negative valence of 2.
E. Acquires or has a positive valence of 3.

47. A radical which borrows an electron.
(1.10)

48. Chlorine. (1.10) **49.** NH_4. (1.10)

50. The valence of the metal in $Al(OH)_3$.
(1.10)

51. A metallic element which lends two electrons.
(1.10)

Item 52 deleted.

53. The formation of molecules through combination of
(1.10) atoms does *not* occur in

A. oxygen. **B.** hydrogen **C.** nitrogen.
D. helium. **E.** two of the above.

54. Both positive and negative valences can be acquired
(1.10) by

A. neon.	atomic number 10.
B. carbon.	atomic number 6.
C. oxygen.	atomic number 8.
D. sodium.	atomic number 11.
E. magnesium.	atomic number 12.

55. A molecule of a gas, in comparison to an atom of gas,
(1.10) is said to have a valence of zero because it

A. is neutral in charge. **B.** has no electrons to lend.
C. is an oxidizing agent. **D.** is a reducing agent.
E. is positively charged.

Items 56 - 61. Select from the key the most closely related description.

KEY

A. Valence of zero.
B. Acquires or has a positive valence.
C. Acquires or has a negative valence.
D. Shares electrons.
E. Shares electrons and may form chains.

56. The behavior of hydrogen in the formation of water.
(1.10)

57. Carbon. (1.10) **58.** Neon. (1.10)

59. An element which lends electrons.
(1.10)

60. The SO_4 radical.
(1.10)

61. The formation of gas molecules.
(1.10)

Items 62 - 65. Select from the key the most closely related description.

KEY

A. Acquires or has a positive valence.
B. Acquires or has a negative valence.
C. Valence of zero.
D. Shares electrons and may form chains.
E. Shares electrons.

62. Argon.
(1.10)

63. An element which borrows electrons.
(1.10)

64. The formation of hydrogen molecules.
(1.10)

65. The formation of water molecules.
(1.10)

66. When the ratio of the charge to the mass (e/m) of the electron was calculated, which one of the following assumptions was made about the electron?
(1.10)

A. The charge on the electron was positive.
B. The electron was a material particle.
C. The electron had no weight.
D. The electron always moves with the velocity of light.
E. The charge on the electron was negative.

67. The valence of a substance designates its
(1.10)

A. state of oxidation. **B.** atomic number.
C. atomic weight. **D.** nuclear charge.
E. radioactive properties.

68. A deuteron is
(1.10)

A. the nucleus of a heavy hydrogen atom.
B. a neutron with two positive charges.
C. an electron with a positive charge.
D. a type of large molecule.
E. an atom of a recently discovered element.

69. Isotypes are elements
(1.10)

A. with two or more forms, like graphite and the diamond.
B. with the same atomic weight but different molecular weights.
C. which have both positive and negative valences.
D. which can exist in two or more states at the same temperature.
E. with the same atomic number but a different number of neutrons.

70. In relative weight, a sodium ion compared to a sodium atom
(1.10)

A. is about the same. **B.** is heavier.
C. is considerably lighter.
D. cannot be compared because an ion has no weight.
E. cannot be compared because an ion is an electrical charge.

71. A chemical element is found to consist of several substances of different atomic weights but identical chemical properties. These substances are called
(1.10)

A. allotropic forms. **B.** isotopes. **C.** electrons.
D. deuterons. **E.** isobars.

72. The atoms of a given element may differ in atomic weight, have different physical characteristics and yet not vary chemically. This is because of a variation in the number of their
(1.10)
(1.30)

A. neutrons. **B.** electrons. **C.** protons.
D. two of the above. **E.** all of the first three.

Items 73 - 78 refer to particles of matter. For each item select from the key the most appropriate response.

KEY

A. Atom. **B.** Electron. **C.** Ion. **D.** Neutron.
E. Proton.

73. A dissociated particle in a solution
(1.10)

74. Particles which are paired to form valence bonds in carbon compounds.
(1.10)

75. The inert gas molecules contain only one of these particles.
(1.10)

76. An uncharged particle which is undisturbed in ordinary chemical reactions.
(1.10)

77. A particle causing an ammeter to give a reading.
(1.10)

78. The particle with the smallest weight.
(1.10)

79. An isotype is
(1.10)

A. a new but unstable element. **B.** a new compound.
C. a form of an element which has different chemical properties but the same weight as another form of that element.
D. an old previously known compound with the same chemical characteristics but a new molecular weight.
E. an atom of an element which has the same chemical characteristics as another atom of the element but different atomic weight.

80. Valence is
(1.10)

A. determined from atomic weight.
B. acquired when protons are lent or borrowed.
C. indicated by the stability of a compound.
D. a measure of the number of electrons shared or exchanged.
E. none of the above.

Items 81 - 83 involve the valence of elements or radicals. For each item select from the key the most closely related description.

KEY

A. Acquires or has a *positive* valence of 1.
B. Acquires or has a *positive* valence of 2.
C. Acquires or has a *positive* valence of 3.
D. Acquires or has a *negative* valence of 1.
E. Acquires or has a *negative* valence of 2.

81. The radical HCO_3. **82.** Calcium.
(1.10) (1.10)

83. Aluminum.
(1.10)

84. A particle which accounts for some elements having several atomic weights is the
(1.10)

A. molecule. **B.** electron. **C.** proton. **D.** ion.
E. neutron.

85. During chemical combinations, metallic atoms always
(1.10)

A. undergo nuclear changes. **B.** gain electrons.
C. lose kinetic energy. **D.** become larger.
E. lose electrons.

86. The valence of a substance designates its
(1.10)

A. nuclear charge. **B.** atomic weight.
C. radioactivity. **D.** state of oxidation.
E. atomic number.

87. An element with a *positive* valence of 2 is
(1.10)

A. calcium. **B.** silver. **C.** aluminum.
D. sulphur. **E.** oxygen.

88. Which one of these has the smallest mass?
(1.10)

A. Neutron. **B.** Electron. **C.** Ion. **D.** Proton.
E. Atom.

89. Numbers expressing how much heavier one kind of atom is than another kind of atom, are known as
(1.10)

A. atomic numbers. **B.** atomic weights.
C. symbols of the elements. **D.** molecular weights.
E. chemical formulae.

90. The present-day table of atomic weights is based upon an arbitrary weight assigned to
(1.10)

A. hydrogen. **B.** salt. **C.** carbon. **D.** water.
E. oxygen.

Item 91 deleted.

92. The number of different fundamental particles which seem to have some part in the make-up of atoms is
(1.10)

A. 4. **B.** 2. **C.** 3. **D.** 8. **E.** more than 10.

93. Isotopes are
(1.10)

A. atoms having the same nuclear charge and the same mass.
B. atoms having different nuclear charges and the same mass.
C. atoms having different nuclear charges and different masses.
D. atoms having the same nuclear charge and different masses.
E. atoms having negative nuclear charges.

94. The valence of an element is
(1.10)

A. the number of its atoms combining with one atom of oxygen.
B. its combining weight divided by its approximate atomic weight.
C. the smallest weight of the element in 22.4 liters (S.T.P.) of any of its gaseous compounds, divided by the combining weight.
D. the number of atoms in its molecule.
E. a single value for a given element.

95. The equivalent (combining) weight of an element is always
(1.10)

A. one-half its molecular weight.
B. its atomic weight, multiplied by the valence.
C. the weight of 22.4 liters (S.T.P.) of the gaseous element.
D. its atomic weight divided by its specific heat.
E. the weight of the element which combines with eight parts of oxygen.

96. Water is *not* used as the standard
(1.10)

A. of specific gravities. **B.** of specific heats.
C. in calibrating thermometer scales.
D. of molecular weights.
E. of the metric system of weights.

97. Ozone
(1.10)

A. is an isotope of oxygen.
B. is an important constituent of the atmosphere.
C. has a volume two-thirds of that of the oxygen from which it was formed.
D. absorbs heat when it is decomposed.
E. is used industrially in the production of high temperatures.

98. Isotopes of a given element differ only in
(1.10)

A. position in the periodic table.
B. number of electrons outside the nucleus.
C. atomic numbers.
D. positive charge of the nucleus.
E. number of neutrons in the nucleus.

99. Electrovalence
(1.10)

A. is the sharing of a pair of electrons between two atoms.
B. results when an electron is transferred from a halide ion to a sodium ion.
C. results when one electron is transferred from a metal atom to a halogen atom.
D. produces compounds which are likely to have low melting points.
E. results in the formation of definite molecules.

100. The atomic number of an element
(1.10)

A. is the number of electrons outside the nucleus.
B. is the number of neutrons in the nucleus.
C. is the number of atoms in 22.4 liters of the gas at S.T.P.
D. follows, for all the elements, the same order as the atomic weights.
E. is the quotient obtained by dividing the atomic weight by the valence.

101. Rutherford developed his nuclear theory of atomic structure because
(1.10)

A. most alpha particles passed through gold foil without serious deflection but a very few were violently deflected.
B. the atomic numbers of the elements were in the same order as their atomic weights.
C. of the enormous amounts of energy liberated by nuclear disintegration.
D. because radium condenses drops from supercooled water vapor.
E. because the frequency of X-rays was proportional to the square root of the atomic number.

102. (1.10) The rare earths

- **A.** are a group of elements whose chemical behavior is very similar because all have eight electrons in the outside shell.
- **B.** are a series of elements which combine with no other elements.
- **C.** are a series of elements whose chemical similarity is due to the fact that the two outermost electron shells are identical.
- **D.** are a group of elements with the same atomic number.
- **E.** are a number of sparsely distributed minerals, whose constituent elements are not yet known.

103. (1.10) A compound

- **A.** is any substance that can be obtained in crystalline state.
- **B.** can only be obtained by the direct combination of its constituent elements.
- **C.** varies slightly in composition according to the proportion of the two elements combined together.
- **D.** is made up of two or more elements combined in unchangeable proportions by weight.
- **E.** is always more stable at low temperature than high temperature.

104. (1.10) The mole is

- **A.** a weight of a substance in grams equal to its molecular weight.
- **B.** an abbreviation for the molecule.
- **C.** the actual number of molecules in 22.4 liters, (S.T.P.), of any gas.
- **D.** the smallest weight of an element in the molecular weights of any of its compounds.
- **E.** a constant obtained by multiplying the specific heat of an element by its atomic weight.

105. (1.10) Concerning the inert gases,

- **A.** argon is used in lifting balloons.
- **B.** helium atoms contain no neutrons.
- **C.** xenon is given off in the disintegration of radium.
- **D.** neon is too rare to have any practical use.
- **E.** krypton has eight electrons in its outermost orbit.

106. (1.10) Silicon

- **A.** has four valence electrons in the atom.
- **B.** forms long chains by linking silicon atom to silicon atom, as does carbon.
- **C.** forms a basic oxide.
- **D.** is found in the free condition in nature.
- **E.** when fused, forms a glass of high transparency.

107. (1.10) The atomic number of an element is numerically equal to

- **A.** the number of protons in the nucleus of the atom.
- **B.** the number of neutrons in the nucleus of the atom.
- **C.** the whole number nearest to its atomic weight.

108. (1.10) The nucleus of an atom consists of

- **A.** electrons and protons.
- **B.** electrons, protons and neutrons.
- **C.** protons and neutrons. **D.** electrons and neutrons.
- **E.** protons only.

109. (1.10) What is the valence of the element Mn in the compound $HMnO_4$?

A. +3. **B.** +4. **C.** +5. **D.** +6. **E.** +7.

110. (1.10) A uranium atom can be seen with

- **A.** an ordinary microscope.
- **B.** a high power microscope.
- **C.** a 200-in. telescope. **D.** an electron microscope.
- **E.** none of these instruments.

111. (1.10) Why is the weight of oxygen a good standard upon which to base the relative atomic weights of other elements?

- **A.** It is heavy. **B.** It is of relatively low density.
- **C.** It unites with many other elements.
- **D.** It is readily available.
- **E.** It unites with no other elements.

For items 112 - 118 mark

- **A.** if it states an observable or experimentally determinable characteristic of the photoelectric effect, and is in accordance with both the classical and the quantum theory of light.
- **B.** if it states an observable or experimentally determinable characteristic of the photoelectric effect, and is in accordance with the quantum theory of light but not with the classical theory.
- **C.** if, while it is not experimentally testable in any fairly direct way, it is a true statement about the photoelectric effect according to both the classical and quantum theories.
- **D.** if, while it is not experimentally testable in any fairly direct way, it is a true statement about the photoelectric effect according to the quantum theory, though not according to the classical theory of light.
- **E.** if it is, according either to experimental results or to the quantum theory, not a true statement about the photoelectric effect.

112. (1.10) The average kinetic energy of the liberated electrons increases if one increases the intensity of the light.

113. (1.10) When light falls upon a metal, it exerts an influence upon the electrons within the metal, and may succeed in ejecting them from it.

114. (2.20) In light of very low intensity, the average amount of energy flowing across a square centimeter in a second may be so small that, considering a region of the size of an atom and assuming uniform distribution of the energy, years would be required for enough energy to flow through such a region to give an electron comparable with that measured in the photoelectric effect. Yet such light falling upon a metal may instantly eject electrons from it.

115. (2.20) When light falls upon a metal, interactions with electrons occur only in the form of encounters between a single electron and a definite, localized, and indivisible portion of the light.

116. (2.20) The speeds with which electrons leave a body in the photoelectric effect may be increased by using light of shorter wave length.

117. (2.20) Electrons can be ejected from a metal only by light whose frequency corresponds to a line in the bright line spectrum of that metal.

118. (2.20) Positive charges are never ejected from a body by the photoelectric effect.

119. (1.10) Planck introduced the quantum postulate into the theory of radiation in order to account for

- **A.** discontinuous spectra. **B.** interference.
- **C.** the constitution of radiation out of finite, corpuscle-like "chunks" of energy, each of which is propagated with great speed in a straight line.
- **D.** the ejection of electrons from matter by light, a phenomenon which indicates in rather direct fashion that the spatial distribution of energy in a light "wave" is discontinuous.
- **E.** the distribution of energy in the spectrum of a black body, a phenomenon which does not involve any obvious discontinuity, but which can be accounted for quantitatively by the postulate.

120. (1.10) The basic discontinuity of "quantization" postulated by Planck in his theory of black body radiation, was a discontinuity in

- **A.** the possible frequencies of vibration of an oscillating charged particle.
- **B.** the possible energies of an oscillating charged particle.
- **C.** the possible energies of an oscillating charged particle of given frequency.
- **D.** the spatial distribution of the energy radiated by an oscillating charged particle.
- **E.** the spatial distribution of the energy radiated by an oscillating charged particle of given frequency and energy.

121. (1.10) Perrin placed a pair of coaxial cylinders in the path of a stream of cathode rays in a tube, so that the rays passed through holes into the inner cylinder. He found that

- **A.** the inner cylinder received a negative charge.
- **B.** the outer cylinder received a negative charge.
- **C.** both cylinders received a negative charge.
- **D.** one cylinder or the other (but not both) received a negative charge.
- **E.** one cylinder or the other or both received a negative charge.

122. (1.10) In order to apply Cannizzaro's method for determining the atomic weight of an element, one *must* know, in addition to composition by weight of several of its compounds,

- **A.** the specific gravities of several compounds in the vapor state.
- **B.** the specific heat of the element.
- **C.** either the data in A or that in B.
- **D.** the specific heats of several compounds of the element.
- **E.** all of the data in A, B, and D.

123. (1.10) Gay-Lussac attributes the regularity of gases, on the one hand, as opposed to the irregularity of solids and liquids, on the other hand, to

- **A.** uniformity of density in gases, not in solids or liquids.
- **B.** effect of attractive forces between molecules in solids and liquids, not in gases.
- **C.** presence of caloric in gases, not in solids or liquids.
- **D.** the presence of discrete particles of substance in gases, not in solids or liquids.
- **E.** ease of determining the densities of the gaseous elements, not of the solid or liquid elements.

124. (1.23) Elements which take on electrons are also classified as

- **A.** oxides. **B.** halogens. **C.** metals.
- **D.** hydaraes. **E.** non-metals.

125. (1.24) (1.30) In the series of active metals (Na, K, etc.), cesium is the most active. The *best* explanation of this is that

- **A.** it has a greater attractive force on valence electrons than the others.
- **B.** its atomic number is greater.
- **C.** its valence electron has an orbit with a greater radius than the others.
- **D.** its incomplete shell or energy level is closer to the nucleus.
- **E.** it has more valence electrons than the others.

126. (1.24) Potassium is more active than sodium because

- **A.** it has a greater number of valence electrons.
- **B.** its valence electron is farther from the nucleus.
- **C.** it accepts electrons more readily.
- **D.** its atomic weight is less than that of sodium.
- **E.** its incomplete shell is closer to the nucleus.

127. (1.24) (1.30) All of these present experimental evidence for the electron theory of matter *except*

- **A.** when a rubber rod is rubbed with fur, the rod becomes charged.
- **B.** hot filaments in radio tubes emit a stream of charged particles.
- **C.** radium disintegrates into other forms, the end product being lead.
- **D.** every body in the universe attracts every other body with a measurable force.
- **E.** certain substances dissociate in solution and become ions.

128. (1.24) The fundamental nature of the atom, that is, the factor or factors which seem(s) to distinguish it from all other kinds of atoms is

- **A.** the charge of the electrons in the electron cloud.
- **B.** the atomic weight of the atom.
- **C.** the charge of the neutrons within the atom.
- **D.** the positive charge on the nucleus of the atom.
- **E.** more than one of the above.

129. (1.24) Which of the following is the best evidence that electrons are arranged in definite orbits or energy levels?

- **A.** Electrons in the beta-ray have a very high energy.
- **B.** All elements do not have identical properties.
- **C.** Electrons rotate about the nucleus.
- **D.** The penetrating power of cathode ray electrons depends on the voltage used to produce them.
- **E.** Atomic spectra consist of sharp lines, not continuous bands of color.

130. (1.25) The mass of an atom is concentrated in a very small part of the total volume of the atom, that is, the nucleus. This statement is substantiated most by the observation that

- **A.** gases can be compressed into very small volumes.
- **B.** gases diffuse through one another.
- **C.** alpha particles penetrate thin sheets of gold.
- **D.** atoms neither gain nor lose mass during chemical reactions.
- **E.** light passes through many substances.

131. (1.25) The relative weights of atoms may be determined most appropriately by the

A. zinc-sulphate fluorescent screen.
B. Wilson cloud chamber. **C.** Geiger counter.
D. mass spectrograph. **E.** electron microscope.

Items 132 deleted.

133. (1.25) The most common, or so-called "classical method," by which the inner structure of atoms has been studied, has been by

A. bombardment of these atoms with small particles or with high-frequency electromagnetic radiation.
B. the use of these atoms as projectiles hurled into the nucleus of heavy molecules.
C. whirling these atoms again and again through an electric field in a cyclotron.
D. the bombardment of alpha particles from radium with a stream of these atoms.
E. speeding up these atoms by placing them between two electrodes in an evacuated tube, and giving the electrodes strong charges of opposite sides or polarities.

134. (1.25) The formula of a compound enables us to state how much heavier one kind of atom is than another, provided we know

A. the relative atomic weights of each of the elements.
B. the ratio in which the atoms combine.
C. how much heavier one atom is than another.
D. how many atoms of each make up a molecule of the compound.
E. more than one of the above is correct.

135. (1.25) An important forward step in the development of atomic theory occurred with proof that the atom is mostly empty space. The experimental procedure involved

A. the radioactive disintegration of certain substances.
B. the Wilson cloud chamber.
C. the use of alpha particles to bombard gold foil.
D. Aston's mass spectrograph.
E. the use of a zinc-sulfide fluorescent screen.

Items 136 - 140 begin with a phrase specifying something to be measured, determined, or produced. After the exercise number on the answer sheet, blacken the *one* lettered space which designates how this goal is to be accomplished.

136. (1.25) The amount of electric charge on a single electron:

A. Use an electroscope. **B.** Use a cathode tube.
C. Use a fog-track apparatus.
D. Use Millikan's oil drop apparatus.
E. Use the mass spectrograph of Aston.

137. (1.25) Whether the nucleus of an atom is small as compared with the total volume of the atom:

A. Use Millikan's oil drop apparatus.
B. Shoot alpha particles through gold foil or use the fog-track apparatus.
C. Use a zinc-sulfide fluorescent screen.
D. Use the mass spectrograph of Aston.
E. Use the Geiger counter.

138. (1.25) Whether or not a given element has isotopes:

A. Seek chemical reactions which will separate different forms.
B. Use the fog-track-apparatus.
C. Use the mass spectrograph of Aston.
D. Use a centrifuge so that the heavier atoms will be separated from the lighter ones.
E. Use a zinc-sulfide fluorescent screen.

139. (1.25) Whether or not a given particle, known to be an electron or a positron, is the latter rather than the former:

A. Observe its path in a zinc-sulfide fluorescent screen.
B. Use the mass spectrograph of Aston.
C. Observe its path in a fog-track apparatus in the presence of a magnetic field.
D. Pass the particle through beryllium foil and observe the result.
E. Observe the direction in which it circles around the nucleus of the atom.

140. (1.25) Whether or not neutrons are present:

A. Use the Geiger counter.
B. Look for evidence of collisions in which there is no fog-track up to the collision.
C. Use the oil drop apparatus of Millikan.
D. Use deuterons in the atom smashing experiment.
E. Compare the observable path of the neutron with that of the electron and proton.

For items 141 - 150 use the following key:

KEY

A. A scientific fact well supported by evidence.
B. A highly probable theory. **C.** A mere guess.

141. (1.30) ( ) An electron revolving around a positive nucleus is subjected to a centrifugal force equal and opposite to the electrostatic force attracting it by the nucleus.

142. (1.30) ( ) The atom for the most part is made up of a nucleus of protons and neutrons with the same number of electrons revolving around the nucleus as protons contained in the nucleus

143. (1.30) ( ) A useful element has been formed by merely projecting a neutron into the nucleus of an atom.

144. (1.30) ( ) Researchers have been able to form many isotopes that have never been discovered as natural particles.

145. (1.30) ( ) When the nature of the force that holds the nucleus of an atom together is determined, an American scientist will be the discoverer.

146. (1.30) ( ) The electron is considered by scientists as the smallest particle of matter.

147. (1.30) ( ) The atom is a tiny solar system with a nucleus of positive charges of electricity at its center and electrons revolving around it.

148. (1.30) ( ) Robert Millikan discovered the value of the electrical charge carried by the electron.

149. (1.30) ( ) The atom has locked in its nucleus a tremendous amount of energy.

150. (1.30) ( ) Within the next fifty years uranium will be used as a fuel in all the larger electrical power plants.

Item 151 deleted.

152. (1.30) A sodium atom (atomic number 11) which has lent an electron in a chemical reaction, that is, has become a sodium ion, contains (Select the most complete answer)

A. only completely filled electronic energy levels.
B. an incompletely filled electronic energy level.

C. a number of electrons greater than the number of protons.
D. a number of protons greater than the number of electrons.
E. two of the above.

153. Which one of these is *not* true?
(1.30)

A. Atoms may share electrons as well as lend or borrow.
B. During chemical combinations, the inner shells of atoms tend to be broken up.
C. When filled, the innermost shell of the atom contains two electrons.
D. There may be certain atoms within a molecule which are held together by sharing electrons and which react as a unit in chemical changes.
E. In the formula of a compound, the total positive valence must equal the total negative valence.

154. The number of chemical bonds which an atom can form
(1.30) can be ascertained from

A. its atomic number. **B.** its atomic weight.
C. its number of neutrons. **D.** the equivalent weight.
E. the number of innermost electrons.

155. Chlorine is a more active non-metal than iodine. This
(1.30) is probably because

A. chlorine loses electrons more readily than does iodine.
B. the incomplete shell of electrons in the chlorine atom is closer to the nucleus than is the one in the iodine atom.
C. iodine adds electrons more readily than does chlorine.
D. the negative valence electron of the chlorine atom is farther away from the nucleus than is the one in the iodine atom.
E. chlorine is an oxidizing agent.

156. Which one of the following should receive one electron
(1.30) in chemical combination?

A. P. **B.** Ne. **C.** Li. **D.** Cl. **E.** O.

157. The equation $Mg + O_2 \rightarrow MgO$ is incorrect because
(1.30) it is not in accord with

A. Avogadro's Law.
B. the Law of Conservation of Mass.
C. the Law of Definite Proportions.
D. the Law of Multiple Proportions.
E. Boyle's Law.

158. The atomic weight of most atoms depends almost en-
(1.30) tirely upon the weight of the

A. electrons of the atom. **B.** protons of the atom.
C. electrons and protons of the atom.
D. protons and neutrons of the atom.
E. electrons and neutrons of the atom.

Item 159 deleted.

Items 160 - 165 refer to various features of atomic structure. For each item select from the key the experimental method that was most important in establishing it.

KEY

A. Measurements with the mass spectograph.
B. Millikan's oil drop experiment.
C. Deflection of cathode rays in a magnetic field.
D. Measurements of the wave lengths of characteristic lines in the X-ray spectra.
E. Deflection of α-particles by foils of metals.

160 The atomic number is equal to the number of extra-
(1.30) nuclear electrons.

161. The charge on the electron is 4.802×10^{-10} esu.
(1.30)

162. The positive charge of the atom is concentrated in a
(1.30) small, compact nucleus.

163. The electrons of an atom are arranged in energy levels
(1.30) about the nucleus.

164. Atoms of the same element may have different atomic
(1.30) weights.

165. The mass of the electron is 9×10^{-28} gm.
(1.30)

166. When two atoms react to form an ionic compound, we
(1.30) assume in accordance with the atomic theory that

A. one or more pairs of electrons are shared in common between the two atoms.
B. one or more electrons are transferred from one atom to the other.
C. the atoms are held together by the electrostatic force between protons and neutrons.
D. the atoms are held together by the force of gravity.

167. A characteristic of the structure of metallic elements is
(1.30) that

A. they tend to share their electrons with other atoms.
B. their atoms are smaller and more compact than those of non-metallic elements.
C. their outermost orbit of electrons is nearly complete and they attract electrons from other atoms.
D. they have only a small number of electrons in their outermost electron orbit which are weakly held and easily lost.

168. Which one of these is explained on the basis of atomic
(1.30) theory rather than on kinetic theory?

A. The explanation of heat of fusion.
B. That the energy of particles may be expressed in terms of $\frac{1}{2} MV^2$.
C. Changes in the state of matter.
D. Conservation of mass.
E. The meaning of temperature.

169. The third shell (or energy level) of an atom of neon
(1.30) (atomic number 10) contains

A. 0 electrons. **B.** 2 electrons. **C.** 8 electrons.
D. 10 electrons. **E.** 18 electrons.

Items 170 - 171 deleted.

172. The alkali metals of group I_a, lithium, sodium, potas-
(1.30) sium, rubidium, and cesium are the most active metals. Cesium is the most active in the list because as one proceeds from lithium to cesium

A. the atomic radius of the valence electron increases.
B. the number of valence electrons increases.
C. the metallic properties become more pronounced.
D. the valence increases.
E. the atomic weight decreases.

Items 173 - 180 refer to the particles which are important in our theories of matter. For each item select from the key the most appropriate response.

KEY

A. Atom. **B.** Electron. **C.** Molecule.
D. Neutron. **E.** Proton.

173. (1.30) The particle most important in the continuance of chain reactions in the fission of uranium.

174. (1.30) The particle most responsible for the reading of a light meter when exposed to suitable radiation.

175. (1.30) The particle of which there is a deficiency when a glass rod is charged positively.

176. (1.30) A particle most frequently discussed in theories of "states" of matter.

177. (1.30) A particle most helpful in explaining how a gas exerts pressure.

178. (1.30) A particle which accounts for chlorine and many other elements being assigned an "average" atomic weight.

179. (1.30) A particle which exists in an ionized state in table salt.

180. (1.30) The smallest particle which can exist and still retain all of the properties of the compound.

181. (1.30)
1. The nucleus of an atom contains only protons and electrons as separate particles.
2. The number of electrons in an atom in the normal state equals the number of protons.
3. The nucleus of an atom contains protons and neutrons.
4. The number of neutrons in an atom always gives the atomic number.
5. An atom may lose one or more electrons in ordinary chemical reactions.

Which of the following choices lists all and only those statements above which are correct according to the theory of the Bohr atom?

A. 1 and 3. **B.** 2 and 4. **C.** 2, 3 and 5.
D. 2, 3 and 4. **E.** 1, 2 and 3.

182. (1.30) In order to determine the relative activity of several non-metals it would be most useful to know the

A. valences of the non-metals.
B. atomic weights of the non-metals.
C. atomic numbers of the non-metals.
D. family to which each non-metal belongs.
E. group to which each non-metal belongs.

Items 183 - 187 refer to comparisons which are frequently made in science. For each item select from the key the most appropriate response.

KEY

A. The first is greater than the second.
B. The first is equal to the second.
C. The first is less than the second.
D. More data is required to compare them.

183. (1.30) The number of electrons in a sodium ion compared to the number of protons in its nucleus.

184. (1.30) The magnifying power of a convex lens with a focal length of 5 cm. compared to one with a focal length of 10 cm.

185. (1.30) The temperature of the sun compared to the temperature of a star.

186. (1.30) The atomic weight of helium compared to its molecular weight.

187. (1.30) The pitch of a closed organ pipe 2 feet long compared to the pitch of an open pipe 4 feet long.

188. (1.30) When H combines with Cl,

A. the valence of H is reduced from +1 to zero.
B. Cl is a reducing agent.
C. electrons are gained by Cl. **D.** H is reduced.
E. the valence of Cl is unchanged.

189. (1.30) The atomic theory assumes all of these *except*

A. the average mass of atoms of the same kind is definite, but different from that of any other kind of atom.
B. the number of different kinds of elements is limited.
C. atoms lose their identity in chemical reactions.
D. atoms possess kinetic energy.
E. all elements are composed of small discrete particles.

For items 190 - 200 select from the key the correct particle.

KEY

A. Neutron. **B.** Electron. **C.** Proton.
D. Atom. **E.** Molecule.

190. (1.30) A particle which travels in elliptical orbits.

191. (1.30) Another name for the hydrogen ion.

192. (1.30) A nearly weightless particle found in all elements.

193. (1.30) The molecule of argon contains only one of what other particle?

194. (1.30) A particle particularly important in the kinetic theory.

195. (1.30) A particle *not* found in a certain *one* of the known elements.

196. (1.30) A particle discussed in the elementary theories of magnetism.

197. (1.30) A particle, for active gaseous elements, containing exactly *two* other particles.

198. (1.30) A particle which may be ionized in chemical reactions.

199. (1.30) A particle important in the operation of a thermocouple.

200. (1.30) A particle which helped explain discrepancies in atomic weights.

201. (1.30) The chemical nature of the atom is determined by the

A. atomic weight. **B.** number of neutrons.
C. electrons. **D.** weight of the protons.
E. size of the neutrons.

202. (1.30) Avogadro's Law is of importance in the

A. determination of the relative weights of molecules.
B. prediction of solar eclipses.
C. determination of the pressure of a gas when the temperature is known.

D. prediction of intensity of discharge of electrons across a spark gap.
E. determination of the rate of disintegration of radioactive substances.

203. Both positive and negative valence may be exhibited by
(1.10)

A. hydrogen. **B.** chlorine. **C.** neon.
D. carbon. **E.** none of the above.

204. The preceding item would have been easier to answer
(1.30) if it had included the

A. atomic weights of the elements.
B. atomic numbers of the elements.
C. series to which the elements belong.
D. relative position in the electro-chemical series.
E. state in which the element normally exists.

205. The loss of a neutron from an atom
(1.30)

A. changes the chemical nature of the atom.
B. changes the charge on the atom.
C. changes the physical properties of the atom.
D. reduces the atomic number of the atom.
E. causes the subsequent loss of an electron.

206. According to the liquid drop model of atomic nuclei all
(1.30) of the following are true *except*

A. there are attractive forces between neutrons and protons when they are close together.
B. the total mass of two separate deuterons is greater than when fused into one particle.
C. if two deuterons fuse they will form an alpha particle.
D. the activation energy of heavy nuclei (above atomic number 50) is the energy used for working against their electrical repulsive forces.
E. activation energy for the fusion of light nuclei is supplied by very high temperatures.

207. A sodium atom (atomic number 11) which has lent an
(1.30) electron in a chemical reaction, that is, has become a sodium ion, contains

A. only completely filled electronic energy levels.
B. an incompletely filled electronic energy level.
C. a number of electrons greater than the number of protons.
D. a number of protons greater than the number of electrons.
E. two of the above.

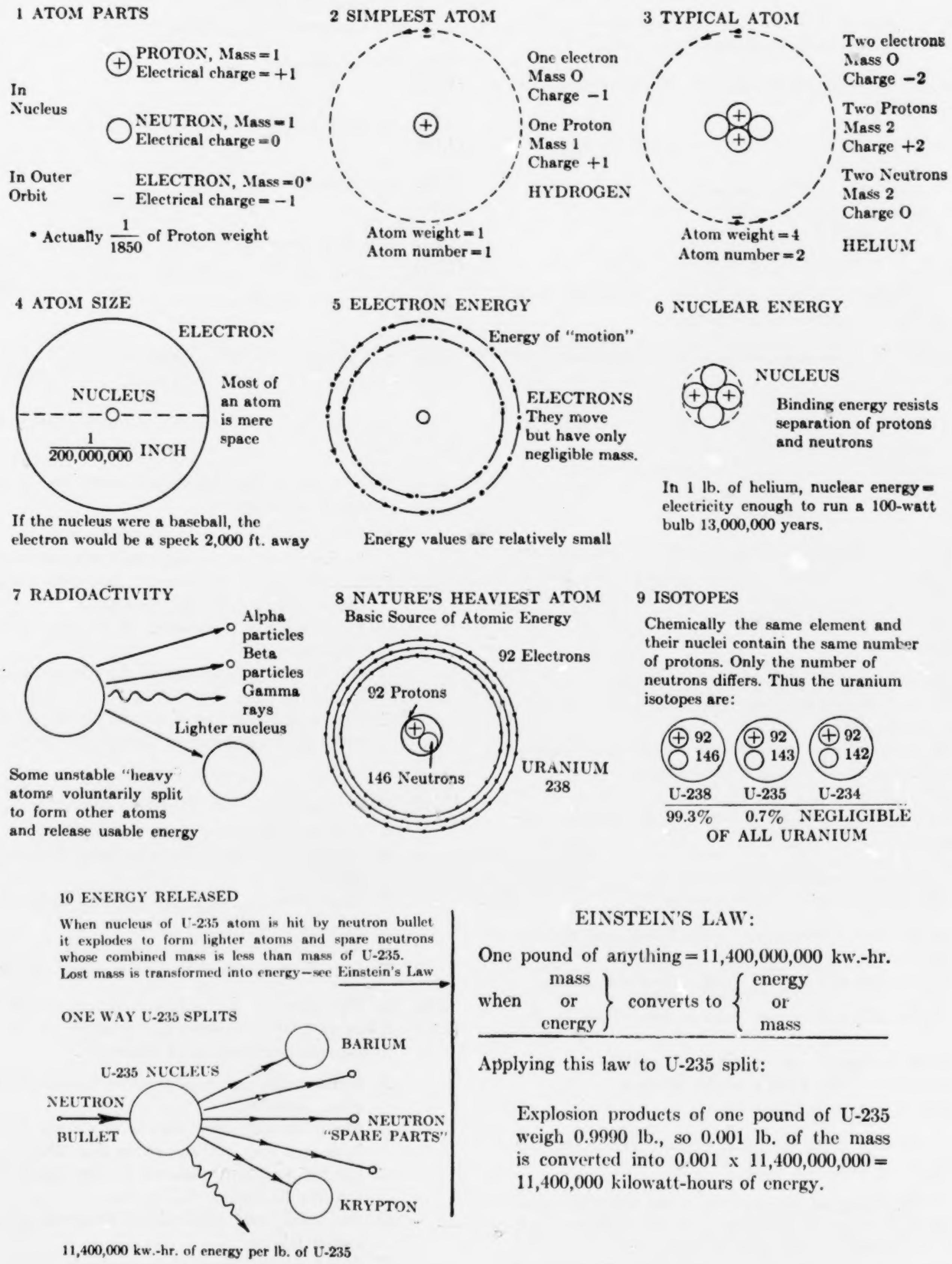
208. A general rule for nuclear stability is
(1.30)

A. instability increases as the charge on the nucleus decreases.
B. a heavier nucleus is usually more stable than a lighter one.
C. when a nucleus contains more protons than neutrons it is unstable.
D. emission of alpha, beta, or gamma particles contributes to increased instability of the nucleus.
E. none of the above offers a general rule.

209. The loss of a neutron from an atom
(1.30)

A. changes the chemical nature of the atom.
B. changes the charge of the atom.
C. changes a physical property of the atom.
D. reduces the atomic number of the atom.
E. causes the subsequent loss of an electron.

Items 210 - 217 refer to the following diagram.


1 ATOM PARTS
In Nucleus
PROTON, Mass = 1
Electrical charge = +1
NEUTRON, Mass = 1
Electrical charge = 0
In Outer Orbit
ELECTRON, Mass = 0*
Electrical charge = −1
* Actually 1/1850 of Proton weight
2 SIMPLEST ATOM
One electron
Mass 0
Charge −1
One Proton
Mass 1
Charge +1
HYDROGEN
Atom weight = 1
Atom number = 1
3 TYPICAL ATOM
Two electrons
Mass 0
Charge −2
Two Protons
Mass 2
Charge +2
Two Neutrons
Mass 2
Charge 0
HELIUM
Atom weight = 4
Atom number = 2
4 ATOM SIZE
ELECTRON
NUCLEUS
1/200,000,000 INCH
Most of an atom is mere space
If the nucleus were a baseball, the electron would be a speck 2,000 ft. away
5 ELECTRON ENERGY
Energy of "motion"
ELECTRONS
They move but have only negligible mass.
Energy values are relatively small
6 NUCLEAR ENERGY
NUCLEUS
Binding energy resists separation of protons and neutrons
In 1 lb. of helium, nuclear energy = electricity enough to run a 100-watt bulb 13,000,000 years.
7 RADIOACTIVITY
Alpha particles
Beta particles
Gamma rays
Lighter nucleus
Some unstable "heavy atoms voluntarily split to form other atoms and release usable energy
8 NATURE'S HEAVIEST ATOM
Basic Source of Atomic Energy
92 Electrons
92 Protons
146 Neutrons
URANIUM 238
9 ISOTOPES
Chemically the same element and their nuclei contain the same number of protons. Only the number of neutrons differs. Thus the uranium isotopes are:
92
146
92
143
92
142
U-238
U-235
U-234
99.3%
0.7%
NEGLIGIBLE
OF ALL URANIUM
10 ENERGY RELEASED
When nucleus of U-235 atom is hit by neutron bullet it explodes to form lighter atoms and spare neutrons whose combined mass is less than mass of U-235. Lost mass is transformed into energy—see Einstein's Law
ONE WAY U-235 SPLITS
BARIUM
U-235 NUCLEUS
NEUTRON BULLET
NEUTRON "SPARE PARTS"
KRYPTON
11,400,000 kw.-hr. of energy per lb. of U-235
EINSTEIN'S LAW:
One pound of anything = 11,400,000,000 kw.-hr.
when mass or energy converts to energy or mass
Applying this law to U-235 split:
Explosion products of one pound of U-235 weigh 0.9990 lb., so 0.001 lb. of the mass is converted into 0.001 x 11,400,000,000 = 11,400,000 kilowatt-hours of energy.

Although the following items refer to the above diagram, they can be answered without the aid of the diagrams. Evaluate the statements according to the key.

KEY

A. The statement is true.
B. The statement is false.
C. The statement is neither true nor false in all cases.

210. (1.30) All atoms must have at least one electron in the nucleus.

211. (1.30) All atoms must have at least one neutron in the nucleus.

212. (1.30) Nuclei of all atoms carry a positive charge.

213. (1.30) All nuclei contain more neutrons than protons.

214. (1.30) The isotopes of uranium cannot be separated by means of chemical processes.

215. (1.30) When an atom disintegrates all of its mass is accounted for in the particles and lighter atoms that are released.

216. (1.30) In the disintegration of uranium, the barium atoms are the product that continues the chain reaction.

217. (1.30) Chemically speaking all but the nucleus of an atom can be disregarded.

218. (1.30) Hydrogen combines easily with non-metals because

A. it is the lightest of the elements.
B. it consists of two electrons. **C.** it is a gas.
D. it has an unfilled electronic energy level.
E. it has a completely filled electronic energy level.

219. (1.30) Select from the following the one correct statement concerning the composition of compounds.

A. Berthollet: "The composition of a compound can vary."
B. Proust: "A pure compound has a fixed composition."
C. Dalton: "One atom of hydrogen plus one atom of oxygen gives one particle of water."
D. Avogadro: "Molecules of elementary gases may consist of several atoms."
E. None of the above is correct.

220. (1.30) Four of the following five statements are assumptions which make up Dalton's Atomic Theory. You are to select the *one* which was *not* formulated as one of Dalton's assumptions, but which is the result of other research.

A. Every element consists of tiny particles.
B. The tiny particles in some elements consist of two or more atoms.
C. The atoms of any one element are all exactly alike.
D. In general, atoms combine in simple ratios.
E. Atoms of one element may combine with atoms of another element to form a new substance or compound.

221. (1.30) Given only the atomic number of an element, which of the following quantities could you find?

A. The number of electrons. **B.** The atomic weight.
C. The number of neutrons in the nucleus.
D. The number of isotopes. **E.** All of the above.

222. (1.30) The chemical nature of the atom is determined by the

A. atomic weight. **B.** number of neutrons.
C. electrons. **D.** weight of the protons.
E. kind of charge in the nucleus.

223. (1.30) In an ordinary atom, the total positive charge on the nucleus is equal to the total

A. positive charge of all electrons in the electron cloud.
B. negative charge of all electrons in the electron cloud.
C. charge, both positive and negative.
D. charge of all neutrons and protons in the electron cloud.
E. charge of all protons and electrons in the electron cloud.

Items 224 - 231 refer to various processes related to atomic or **molecular** structure. For each item select from the key the **changes** involved in the operation of the process.

KEY

A. Electron changes between atoms.
B. Alteration in the number of protons and neutrons.
C. Alteration in the number of neutrons only.
D. No change in the number of electrons, protons, or neutrons in the atom.
E. Changes in all particles.

224. (1.30) Photosynthesis.

225. (1.30) Rubbing a glass rod with a piece of silk.

226. (1.30) Distillation.

227. (1.30) Ordinary chemical reaction.

228. (1.30) Isomerism in carbon compounds.

229. (1.30) Ionization. **230.** (1.30) Fission.

231. (1.30) Changes in atomic weight without change in atomic number.

232. (1.30) Which one of the following statements about atomic theory is *incorrect?*

A. There are particles in the nucleus which add mass to the atom but do not affect the electrical charge.
B. The volume of an atom is not determined by the space occupied by the nucleus.
C. Each atom is composed of a negatively charged nucleus.
D. Almost the entire mass of the atom is concentrated in the nucleus.
E. The atomic number of an atom is the same numerically as the number of protons in the nucleus.

233. (1.30) If an atom has one or two electrons in the outer electron orbit, it will have the greatest tendency to

A. gain enough electrons to form eight.
B. change some electrons from inner shells to the outer shell.
C. take electrons from the nucleus and put them in the outer shell.
D. lose electrons from the outer shell.
E. gain electrons from the outer orbit into the nucleus.

234. (1.30) In the underwater explosion of an atomic bomb at Bikini in 1946, a fusion chain reaction of the hydrogen in the water did not occur because

A. ocean water has enough salts in solution to absorb extra neutrons.
B. the possibility of a release of energy by fusion of hydrogen was not known at that time.
C. the temperature produced by the atomic bomb was too low to initiate the reaction.
D. the bomb was particularly designed to prevent a fusion reaction.
E. direct fusion of protons proceeds at a very slow rate even in the interior of stars.

235. (1.30) According to our ideas of atomic structure, we say that it takes more electrical energy to remove an electron from a helium atom than from a hydrogen atom because

A. helium initially has two electrons.
B. the helium nucleus has a greater mass.
C. the helium nucleus has a greater charge.
D. when hydrogen converts to helium (as in the stars) energy is released.
E. helium has neutrons in its nucleus.

Items 236 - 241. After the number on the answer sheet which corresponds to that of each of the following items, blacken space

A. if the item is true of atomic number.
B. if the item is true of mass number.
C. if the item is true of atomic weight as given in the periodic table.
D. if the item is true of atomic size or volume.

236. (1.30) The different isotopes of a given element differ in this respect, for example U-235 and U-238.

237. (1.30) Determines the position of every element listed in the periodic table.

238. (1.30) Is most closely related to the ease with which an element in any given group in the periodic table gains or loses electrons from the highest energy level.

239. (1.30) Can be determined for each isotope of an element by deflection of gaseous ions of the element in electrostatic and electromagnetic fields.

240. (1.30) None of the individual atoms of an element may have the value of this. It is a kind of average of the values pertaining to the isotopes of the element.

241. (1.30) (1.30) Equals the number of planetary electrons in the neutral atom of an element.

242. All atoms, with the exception of $^{1}_{1}H$, are composed of

A. ions, plutons and cathode rays.
B. molecules, geigers and electrons.
C. neutrons, electrons and alpha particles.
D. radioactivity, lead and protons.
E. protons, electrons and neutrons.

Items 243 - 251. After each item on the answer sheet, blacken space

A. if the item is true only of elements.
B. if the item is true only of compounds.
C. if the item is true only of mixtures.
D. if the item is true of both elements and compounds.

243. (1.30) Consists of the same atomic species.

244. (1.30) Have properties entirely different from those of the constituents.

245. (1.30) Have properties dependent on the ratios of the substances present.

246. (1.30) Are listed according to increasing atomic numbers on the periodic chart.

247. (1.30) Energy is gained or lost when formed from simpler materials.

248. (1.30) Usually classified as covalent or electrovalent.

249. (1.30) Usually classified as metals, non-metals or inert gases.

250. (1.30) Are homogeneous, that is, the same throughout.

251. (1.30) Can be easily separated by chemical, mechanical or physical means.

252. Have a definite composition of unlike atoms.

Items 253 - 262. After each item number on the answer sheet, blacken space

A. if the item is true only of mixtures.
B. if the item is true only of elements.
C. if the item is true only of compounds.
D. if the item is true of both elements and compounds.

253. (1.30) Consists of a single variety of atoms.

254. (1.30) Always have a definite and constant composition.

255. (1.30) Its formation from simpler materials is always accompanied by a loss or gain of energy.

256. (1.30) Are identified by specific physical and chemical properties.

257. (1.30) A planned arrangement results in the periodic classification.

258. (1.30) Properties of the components are retained in the material.

259. (1.30) Can be approximately classified as metals or non-metals.

260. (1.30) Can be approximately classified as covalent or ionic.

261. (1.30) Have a definite composition of unlike atoms.

262. (1.30) Have an indefinite composition of unlike atoms.

263. (1.30) In order to determine the atomic number of *any* atom, it is sufficient to know the number of

A. protons in the nucleus.
B. neutrons in the nucleus.
C. protons minus the number of electrons.
D. protons minus the number of neutrons.
E. neutrons plus the number of protons.

264. (1.30) The fact that sodium chloride and similar compounds are solids with high melting and boiling points is attributed to the

A. sharing of electrons.
B. electrostatic forces holding the ions together.
C. fact that the positive ions are metals.
D. crystalline character of such compounds.

265. (1.30) The mass of an atom is most closely related to the sum of the masses of its

A. protons alone. **B.** protons and electrons.
C. protons and neutrons. **D.** neutrons alone.

266. (1.30) Avogadro's Law

A. led to the discovery of the law of combining volumes.
B. states that at S.T.P. equal volumes of all gases contain equal numbers of atoms.
C. states that the product of the molecular weight and the specific heat of all gases at S.T.P. is approximately 6.
D. states that the Avogadro number is 22.4.
E. explains why the volumes of reacting gases are in the ratio of small whole numbers.

267. Concerning matter in the crystalline state
(1.30)

A. a high electrical conductivity is evidence of an electrovalent compound.
B. the density is always higher than that of the same substance in the liquid state.
C. low melting point is usually characteristic of a molecular crystal.
D. all elements fall in the category of atomic crystals with covalent bindings.
E. the vapor pressure is equal to 760 mm. at the melting point.

268. The Bohr picture of the atom
(1.30)

A. was devised to explain combining weights.
B. fails to explain why rapidly moving alpha particles ionize gases.
C. explains a negative electrovalence of *one* by setting up the electron configuration 2, 8, 9.
D. explains the line spectra of elements.
E. explains the complete ionization of electrovalent compounds.

269. Covalent bonds are due to
(1.30)

A. the attraction between ions of opposite charge.
B. the gain or loss of electrons by atoms.
C. the transfer of electrons from one atom to another.
D. the lattice structure of the crystal.
E. the sharing by atoms of two electrons for each valence bond.

270. Electrovalent compounds
(1.30)

A. are always more difficult to decompose chemically than covalent compounds.
B. are the only substances which form crystal lattices.
C. are only produced among elements in the first four groups of the periodic table.
D. nearly always form brittle solids of high melting point.
E. conduct electricity well because they contain free electrons.

271. The Law of Combining Weights states
(1.30)

A. that the elements combine in integral ratios by weight.
B. that the weights of the elements which combine with eight grams of oxygen are integrally related.
C. that the weight of 22.4 liters (S.T.P.) of any element is equal to its atomic weight.
D. that the different weights of one element that combine with eight parts of oxygen, or with that weight of another element which combines with eight parts of oxygen, are multiples of the lowest weight in that series.
E. that the combining weights of the elements are in the same order as their atomic numbers.

272. The Atomic Theory of Dalton
(1.30)

A. was unable to account for the fact that two elements sometimes combine in more than one proportion by weight.
B. put forward the idea that atoms are made of positive nuclei and negative electrons.
C. supposed that the weights of all atoms were integral multiples of that of hydrogen.
D. was not sufficient of itself to establish the relative atomic weights of the atoms with certainty.
E. led to the discovery of the law of combining weights.

273. In the diamond,
(1.30)

A. unbound electrons are abundant.
B. all the four electrons of each carbon atom are used in firmly binding that carbon atom to four other carbon atoms.
C. the molecules have the formula C_8.
D. separate planes of carbon atoms slip over one another easily, under slight pressure.
E. the crystal is held together by electrovalent bonds.

274. According to the Bohr theory, visible radiations of light from atoms or molecules are directly due to
(1.30)

A. small particles ejected from the nuclei of the atoms.
B. photons absorbed by the atoms.
C. revolution of the electrons in their orbits.
D. electrons jumping from an inner to an outer orbit.
E. electrons falling from an outer to an inner orbit.

275. The atomic number of a certain element is 53. An atom of this element must contain
(1.30)

A. 53 neutrons. **B.** 26 neutrons and 27 protons.
C. 1 neutron, 26 protons and 26 electrons.
D. 53 electrons. **E.** 53 particles of all kinds.

276. Sodium metal combines with the gas C to form the compound NaCl. Sodium is a very electropositive metal, chlorine **is a** very electronegative substance. Which of the following *is* true?
(1.30)

A. Sodium accepts an electron from the chlorine atom to form an ionic compound.
B. The bonding between sodium and chlorine is covalent.
C. Sodium is reduced to the +1 valence state.
D. Chlorine is reduced to the −1 valence state.
E. None of the above are true.

277. In which of the following ways did the discovery of isotopes change our ideas of the nature of atoms?
(1.30)

A. It demonstrated that atoms can be broken down into smaller particles.
B. It demonstrated that there is no such thing as a pure atom.
C. It has made the distinction between an atom and a molecule less clear.
D. It indicated that the mass of the atom does not determine its chemical properties.
E. It indicated that an element probably does not consist of atoms.

278. Atoms of the element silicon contain 14 protons. How many electrons are there in the outer valence electron shell of the silicon atom?
(1.30)

A. This cannot be determined from the number of protons.
B. 14. **C.** 12. **D.** 6. **E.** 4.

279. Which of the following is most important in predicting the chemical properties of a given element?
(1.30)

A. The number of protons in the nucleus.
B. The number of neutrons in the nucleus.
C. The sum of the protons and neutrons in the nucleus.
D. The charge on its ion.
E. The number of electron energy levels in the atom.

280. (1.30) Gay-Lussac demonstrates the plausibility of his hypothesis that there is a simple ratio between the volumes of the gaseous elements which combine to form a compound by

A. showing how it may be used in computing the specific densities of gaseous compounds.
B. measuring the volumes of combining elements before and after combination.
C. using the specific densities of the elements to convert the proportions by weight of known compounds to proportions by volume.
D. making predictions as to the specific density of gaseous compounds from his hypothesis, checking the predictions with actual measurements.
E. finding the volumes of combining elements sometimes by direct measurement and sometimes by conversion from the percentage composition of the compound by weight.

281. (1.30) According to Gay-Lussac, the evidence that solids and liquids do not obey simple and regular laws under similar conditions is that

A. the rate of change of volume with other conditions is different for different solids and liquids.
B. the rate of change of volume with other conditions is not constant for the same solid or liquid.
C. the combining volumes of two non-gaseous substances are not constant.
D. all of the foregoing. **E.** none of the foregoing.

282. (1.30) The experimental result expected, according to Bergmann's theory of affinities, if a substance X has more affinity for oxygen than has a substance Y, is that

A. X combines with oxygen but not with Y.
B. a mixture of X and Y, after treatment with oxygen, forms only the substance Y and a combination of oxygen and X.
C. oxygen combines with both X and Y but the combination with X is formed in greater amount.
D. the ultimate particles of X have a greater mass than those of Y.
E. no combination of oxygen and Y is known.

283. (1.10) Berthollet's method of refuting Bergmann's theory consisted principally in

A. pointing out internal inconsistencies in Bergmann's reasoning.
B. showing that the relative concentrations of reacting substances are the factor determining which combinations take place.
C. showing that substances change places in Bergmann's order of affinities under certain circumstances.
D. substituting a theory which explains the same phenomena equally well and more simply.
E. demonstrating that some substances show no affinities at all.

284. (1.10) Berthollet's principal conclusion is that

A. the extent to which a combination takes place depends on the amounts of reacting materials as well as the affinities involved.
B. an order of elective affinities is impossible to determine.
C. elective affinities must be determined by theoretical means.
D. if A + XY yields AX + Y, then Y + AX yields A + XY.
E. the speed of a reaction depends on the concentrations of the substances reacting.

285. (2.20) How may Berthollet's paper best be characterized?

A. It is concerned primarily with observable phenomena and empirical generalizations to be drawn from them.
B. It consists of a treatment of the constitution of matter.
C. It consists of precepts for formulating and testing deductions from abstract hypotheses.
D. It consists of a rigorous experimental proof of a theory that compounds may be formed under some conditions but not under others.
E. It is an extension of Lavoisier's method of classification to chemical reactions.

286. (2.00) In this respect Berthollet's paper is most like that of

A. Lavoisier. **B.** Dalton. **C.** Gay-Lussac.
D. Avogadro. **E.** Cannizzaro.

Items 287 - 290. The first set of relationships established by Bohr in his discussion of systems consisting of a single electron revolving about a nucleus is given by the formulae:

$$\omega = \frac{\sqrt{2}}{\pi}\,\frac{W\sqrt{W}}{eE\sqrt{m}}, \quad 2r = \frac{eE}{W}$$

where ω is the orbital frequency of an electron of charge $-e$ and mass m moving about a nucleus of charge E in an orbit of radius r and ionization energy W.

287. (2.20) These formulae are valid

A. for any body moving under the influence of a force directed to a fixed point and of magnitude eE/r^2, where r is the distance from that point.
B. for any system of atomic dimensions which consists of a single electron moving about a fixed positive charge.
C. for any system of atomic dimensions which consists of a single electron moving in a stationary orbit about a fixed positive charge.
D. for any system of atomic dimensions which consists of a single electron moving about a fixed positive charge, equal and opposite to the charge of the electron.
E. for any system of bodies whose energy is quantized according to the Planck-Einstein hypothesis.

288. (4.20) The importance of these relationships in Bohr's theory lies in the fact that

A. they give the radius of the orbit and the frequency of revolution as functions of the charge of the electron.
B. they give the radius of the orbit and the frequency of revolution as functions of the charge of the nucleus.
C. they give the radius of the orbit and the frequency of revolution as functions of the ionization energy.
D. they express Bohr's hypothesis concerning the necessary and sufficient conditions for the existence of stationary states.
E. they determine the size of the atom.

289. These relationships are not sufficient for the purposes of
(4.20) Bohr's investigation because

A. they do not explain how stationary orbits are at all possible.
B. they do not determine a discrete set of possible energy states of the atom, but rather admit of a continuous set of energies and orbits.
C. they do not determine ω and r uniquely, but leave open a whole set of possible values for them.
D. they do not show the relation of ω and r to one another.
E. they do not show the relation of ω and r to Planck's constant.

290. In deriving the formulae discussed in the preceding
(2.00) three questions, Bohr

A. rejects both Newtonian mechanics and Maxwellian electrodynamics.
B. makes use of Newtonian mechanics in a modified form, but rejects Maxwellian electrodynamics.
C. applies Newtonian mechanics without modifications, but rejects part of Maxwellian electrodynamics, making use only of Coulomb's law.
D. makes use of Newtonian mechanics and of Maxwellian electrodynamics, both in a modified form.
E. applies both Newtonian mechanics and Maxwellian electrodynamics rigorously, since he postulates that these theories hold for the stationary states of atoms, and are inapplicable only to transitions.

291. Rutherford's formula for the probability P of a deflec-
(2.00) tion between ϕ_1 and ϕ_2 for an α particle traversing a metal foil of thickness t is:

$$P = \frac{4\pi n t N^2 e^4}{m^2 u^4} \quad (\cot^2\frac{\phi_1}{2} - \cot^2\frac{\phi_2}{2})$$

The quantities t, n (number of atoms per cubic centimeter), e, m, and u can be determined independently.

The quantity N can best be determined

A. from the atomic weight of the metal.
B. by observing the fraction of particles deflected through angles between ϕ_1 and ϕ_2 (for some given values of ϕ_1 and ϕ_2)
C. by measuring the deflection of some one α particle.
D. from the value of the charge of an electron.
E. by dividing some interval (ϕ_1, ϕ_2) into equal parts and calculating the probability of a deflection for each part of the interval, comparing these with the net probability for the interval as a whole.

292. The quantity u, the initial speed of the α particles, can
(2.00) best be measured by

A. sending the same beam of α particles through metal foils of different thickness, and comparing the average deflection with the thickness in each case.
B. sending the same beam of α particles through metal foils of different thickness, and comparing the various results for the fraction of particles deflected through a given angle.
C. determining the minimum thickness of a given substance required to stop all of the α particles.
D. determining the force exerted by the beam of α particles upon a static electric charge of known magnitude at a given distance from the beam, and the rise in temperature produced in a block of metal when the beam falls upon the block and is completely stopped.
E. subjecting the beam of α particles to electric and magnetic fields at right angles to the beam, adjusting the intensities E and H until no deflection is produced, and applying the law that the electric force on a charge q moving with speed u is Eq, the magnetic force Hqu.

293. According to Rutherford's calculations, the deflection ϕ
(2.00) of an α particle of mass m, initial speed u, and charge 2e, moving initially so as to pass at a distance of p an atomic nucleus of charge Ne, is given by the equation:

$$\cot\frac{\phi}{2} = \frac{mu^2}{2Ne^2}\,p.$$

The derivation of this equation is based upon the assumption

A. that the probability of a given deflection is proportional to the target area presented by the region capable of producing such a deflection.
B. that the probability of a given deflection is the same as the fraction of particles which experience that deflection.
C. that multiple scattering does not occur.
D. that the force on an α particle varies inversely as the square of its distance from an atomic center.
E. that multiple scattering does not occur, and that the force on an α particle is inversely proportional to the square of its distance from an atomic center.

294. The chief significance, for Rutherford's investigation, of
(4.20) the hypothesis of single scattering is that

A. it makes possible the deduction of the equation cited in the preceding item.
B. it explains the deflection of an α particle through a large angle.
C. it explains how the mass and charge of an atom can be concentrated in a nucleus.
D. it establishes a simple relationship between scattering of α and of β particles.
E. it enables one, by means of the equation cited in the preceding item, to conclude from the observed deflection of an α particle what the distance p is between its initial path and the nucleus of some atom.

295. Thomson's concept of the arrangement of electric
(2.00) charges in the atom is derived chiefly from considerations concerning

A. the spectra of elements.
B. the theory of multiple scattering of α and β particles.
C. the periodic table.
D. the possible stable arrangements of charges.
E. the photoelectric effect.

296. Which of the following is a piece of evidence, not avail-
(2.00) able to Rutherford at the time of his experiments on α particle scattering, which today provides overwhelming confirmation of the view that atoms are built of charged particles?

A. The existence of an uncharged particle, the neutron, which can be scattered by atomic nuclei, but which follows a scattering law quite different from that of the α and β particles.
B. The identity of α particles with charged atoms of helium.
C. The identity of β particles with the particles composing cathode rays.

D. The success of Bohr's theory of the atom in accounting for the periodic table of the elements.
E. The formula for the wave lengths in the line spectrum of hydrogen.

297. (2.00) In order to determine the atomic weight of an element by Dalton's method, it is sufficient to know

A. the composition by weight of a compound of the element.
B. whether compounds of the element are binary, ternary, etc.
C. both the composition by weight of a compound of the element, and the class (i.e., binary, ternary, etc.) to which the compound belongs.
D. the composition by weight of a large number of compounds of the element.
E. the density of the element relative to that of the standard element.

298. (2.00) Avogadro postulates that molecules are composed of more than one "elementary molecule" since

A. the different gaseous elements have different specific densities.
B. some gases apparently contract when combining.
C. his postulate about number of molecules in a volume of gas would otherwise be inconsistent with the ratios between combining volumes of gases.
D. his postulate about the number of molecules in a volume of gas would otherwise be inconsistent with the ratios between total volumes of component gases and the volumes of the compound gases.
E. this is the simplest hypothesis possible.

299. (2.00) Avogadro postulates an equal number of molecules in equal volumes of gas under the same conditions primarily on the grounds that

A. the laws of combining volumes of gases can be deduced directly from this postulate.
B. the laws involving temperature, pressure and volume of gases can be deduced directly from this postulate.
C. Dalton's observed atomic weights are inconsistent with Dalton's hypotheses about chemical combination.
D. this furnishes an adequate explanation of the simple combining ratios by volume observed in gas reactions.
E. correct molecular weights are obtainable by application of the postulate.

300. (2.00) Suppose one of the compounds of elements Q and R consists of *exactly* 25% Q and 75% R by weight. What additional information is required in order to calculate the ratio of atoms of Q and R in the compound?

A. The molecular weight of the compound.
B. The combining volumes of Q and R involved in the formation of the compound.
C. The relative atomic weights of Q and R.
D. The actual weights of atoms of Q and R.
E. No additional information is required.

301. (2.00) Which of the following statements is incompatible with the conclusion that the formula of this compound is QR_3?

A. Atoms of a given element are alike in weight, etc.
B. One of the compounds of a given two elements must be binary.
C. Atoms of different elements differ in weight.
D. Compounds of indefinite composition may be formed.
E. None of these is incompatible.

302. (2.10) An atom has 3 protons and 4 neutrons in its nucleus. The number of planetary electrons in the atom is

A. 4. **B.** 3. **C.** 7. **D.** 12.
E. unpredictable.

303. (2.10) The atomic number of the atom in the preceding item is

A. 4. **B.** 3. **C.** 7. **D.** 12.
E. none of these.

304. (2.10) The atomic number of lithium is 3. Some atoms of lithium have 3 neutrons but most have 4 neutrons so that the atomic weight is 6.9. This shows that lithium

A. has two valences. **B.** is not a pure substance.
C. exists as two isotopes. **D.** has a negative valence.
E. has several distributions of its electrons.

305. (2.10) If the nucleus of a neutral atom is assumed to consist of 22 neutrons and 18 protons, the atomic number of the atom would be

A. 40. **B.** 22. **C.** 18. **D.** 4.
E. none of these.

306. (2.10) The atomic weight of carbon is 12 and that of oxygen is 16. The weight, at standard conditions, of 1 liter of carbon dioxide is

A 2.4 grams. **B.** 22400 grams. **C.** 44 grams.
D. 1.96 grams. **E.** none of these.

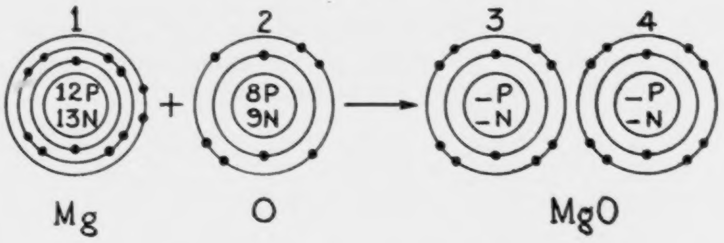
307. (2.10) Cupric copper has a positive valence of two which means that

A. there are six valence electrons in the outer shell of the copper atom.
B. there are two more protons than electrons in the free atom.
C. two electrons are needed to complete the outermost shell of the copper atom.
D. two electrons are always shared in chemical combination.
E. two electrons have been lent in chemical combination.

308. (2.10) In chemical equations where two gases combine to form a gaseous product, the relationship of the volumes of the reacting substances to that of the product formed is shown by the

A. molecular weight. **B.** subscripts.
C. equality between the sum of the volumes of reactants and the volume of the product.
D. ratios of the coefficients.
E. valence of the substances.

Items 309 - 313 refer to the following diagrams.



309. (2.10) The molecular weight of magnesium oxide is

A. 20. **B.** 21. **C.** 22. **D.** 42.
E. none of the above.

310. (2.10) The number of protons and neutrons in ion number four is

A. 9 p, 9 n. **B.** 7 p, 10 n. **C.** 8 p, 9 n.
D. 8 p, 10 n. **E.** 7 p, 8 n.

311. (2.10) The atomic weight of atom number one is

A. 12. **B.** 13. **C.** 24. **D.** 25. **E.** 26.

312. (2.10) Atom number two is

A. of positive valency. **B.** ionized. **C.** inactive.
D. a reducing agent. **E.** non-metallic in character.

313. (2.10) Ion number three in the compound has been

A. oxidized and is now a negative ion.
B. oxidized and is now a positive ion.
C. reduced and is now a negative ion.
D. reduced and is now a positive ion.
E. made neutral.

Items 314 - 316 refer to the electromotive series. In the series, hydrogen is listed at zero potential. Above hydrogen the potentials increase positively and below it the potentials increase in the negative sense, e.g., Al has a potential of +1.67 while gold has a potential of —1.68. Zn will displace H from dilute acids and Zn will displace Ag from salts of Ag. The tendency to go to the reduced state increases as one proceeds from top to bottom in the series, while the tendency to go to the oxidized state increases from gold to sodium.

Partial List of Series

Na—sodium
Mg—magnesium
Al—aluminum
Zn—zinc
Fe—iron
Sn—tin
Pb—lead
H—hydrogen
Cu—copper
Ag—silver
Au—gold

314. (2.10) In chemical reaction one might predict that

A. Cu will displace H from acids.
B. Cu will displace Pb from Pb salts.
C. H with zero potential is inert.
D. Sn will displace Cu from Cu salts.
E. Au is more readily oxidized than Al.

315. (2.10) The positions of gold and sodium indicate that

A. gold is relatively soft, sodium is not.
B. sodium is non-metallic, gold is not.
C. sodium has a complete outer ring of electrons, gold does not.
D. gold is resistant to corrosion, sodium is not.
E. sodium is an integral part of acid salts, gold is not.

316. (2.10) Which one of the following expressions is impossible according to the theory of the electromotive series? (Some of these may not be balanced.)

A. $Zn + SnCl_2 \rightarrow ZnCl_2 + Sn$.
B. $Fe + AlCl_3 \rightarrow FeCl_3 + Al$.
C. $Na + H_2O \rightarrow NaOH + H_2$.
D. $Zn + Cu^{++} \rightarrow Zn^{++} + Cu$.
E. None of the above is impossible.

For items 317 - 321, refer to the information in the key about the five elements listed.

KEY

	atomic number	atomic weight	electronic structure
A.	6	12	2 : 4
B.	11	23	2 : 8 : 1
C.	18	40	2 : 8 : 8
D.	12	24	2 : 8 : 2
E.	17	35	2 : 8 : 7

(Electronic structure refers to the number of electrons in the respective orbits.)

317. (2.10) The most active metal listed.

318. (2.10) An inert element.

319. (2.10) The element having exactly 18 neutrons in the nucleus.

320. (2.10) The best reducing agent in the list.

321. (2.10) An element forming compounds by sharing electrons.

322. (2.10) In chemical combination, a substance with atomic number 12 should acquire a valence of

A. —1. **B.** +1. **C.** —2. **D.** +2.
E. none of these.

323. (2.10) Beryllium has an atomic number of 4. Its valence should be

A. 3. **B.** —2. **C.** 1. **D.** —1.
E. none of these.

324. (2.10) In the reaction, $Sn + 4\ HNO_3 \rightarrow SnO_2 + 4\ NO_2 + 2\ H_2O$, each atom of tin (Sn)

A. gains 2 electrons. **B.** gains 4 electrons.
C. loses 2 electrons. **D.** loses 4 electrons.
E. does none of these.

325. (2.10) In chemical combination, a substance with an atomic number of 12 should

A. acquire a valence of —1.
B. acquire a valence of +2.
C. acquire a valence of —2.
D. acquire a valence of +4. **E.** be inert.

326. (2.10) If an atom has 9 protons and 10 neutrons in its nucleus, and 9 planetary electrons, its atomic weight is probably

A. 9. **B.** 10. **C.** 18. **D.** 19. **E.** 28.

Items 327 - 331 concern various elements or compounds and their valences. For each item select from the key the proper numeric value.

KEY

A. One. **B.** Two. **C.** Three. **D.** Four.
E. Six.

327. (2.10) The total negative valence of $Mg_3(PO_4)_2$, magnesium phosphate.

328. (2.10) The total negative valence of HCO_3, bicarbonate.

329. (2.10) The total positive valence of $KClO_3$, potassium chlorate.

330. The valence of ferric iron.
(2.10)

331. The total positive valence of gypsum, $CaSO_4 \cdot 2H_2O$.
(2.10)

332. If strontium and sulfur react exerting their normal valences, the formula of the product would most likely be
(2.10)

A. Sr_3S. **B.** SrS. **C.** Sr_3S_2. **D.** Sr_2S_3.
E. SrS_3.

333. The valence of the metal in the positive part of the formula $Mg_3(PO_4)_2$ is
(2.10)

A. one. **B.** two. **C.** three. **D.** four. **E.** six.

334. In the preceding formula, the *total* negative valence is
(2.10)

A. two. **B.** three. **C.** four. **D.** six. **E.** eight.

335. If an atom has 9 protons and 10 neutrons in its nucleus, and 9 planetary electrons, its atomic weight is probably
(2.10)

A. 9. **B.** 10. **C.** 18. **D.** 19. **E.** 28.

For items 336 - 340, select from the key the appropriate valence.

KEY

A. Valence 2. **B.** Valence 3. **C.** Valence 4.
D. Valence 5. **E.** Valence 6.

336. Pb in the formula PbO_2.
(2.10)

337. N in N_2O_5.
(2.10)

338. Cr in Cr_2O_3.
(2.10)

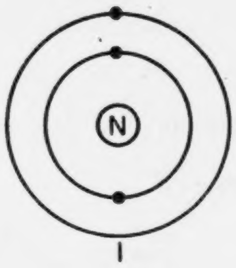
339. S in SO_3.
(2.10)

340. SiO_4 in Na_4SiO_4.
(2.10)

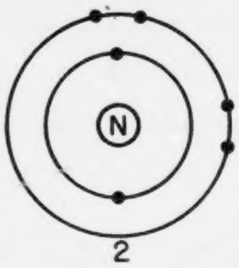
341. A non-metallic element has an atomic number of 8. Its valence on combining is
(2.10)

A. +1. **B.** +2. **C.** −1. **D.** −2.
E. none of these.

Items 342 - 347 refer to the following diagrams.



1



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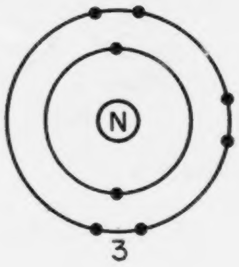

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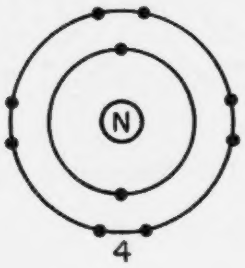


4

The diagrams symbolize the electron configurations of the atoms of four different elements. Indicate which diagram would most probably represent the element described in the statements. If none applies, mark space 5.

342. Cannot be converted to a gas without decomposing.
(2.10)

343. Will lose or gain electrons with almost equal ease.
(2.10)

344. Oxidizes other substances readily.
(2.10)

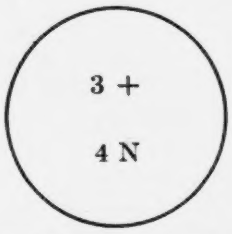
345. Has the highest atomic number.
(2.10)

346. Least apt to form compounds.
(2.10)

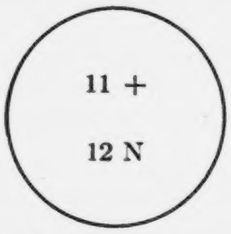
347. The best reducing agent.
(2.10)

348. The valence of magnesium (Mg) is +2, while that of fluorine (F) is −1. What would be the formula of magnesium fluoride?
(2.10)

A. Mg_2F. **B.** MgF. **C.** Mg_2F_2. **D.** Mg_4F.
E. MgF_2.



Lithium Nucleus



Sodium Nucleus

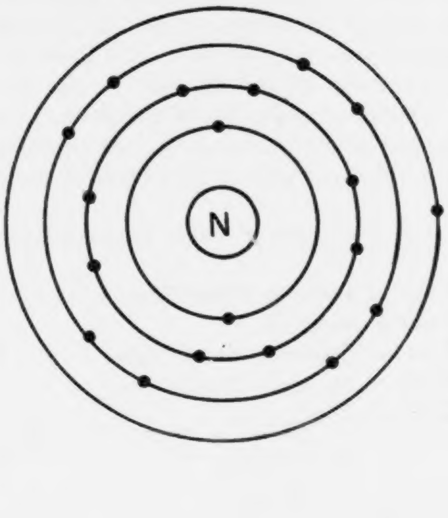
349. From the above diagrams, which of the following statement(s) is (are) true?
(2.10)

A. Both elements are inactive.
B. Sodium is more active than lithium.
C. Both atoms have one electron in the outer orbit.
D. Two of the above are true.
E. All of the above are true.

350. Helium has an atomic weight of 4. This means that
(2.10)

A. an atom of helium weighs as much as four atoms of oxygen.
B. a molecule of helium contains four atoms.
C. four molecules of helium weigh a gram.
D. four atoms of helium weigh a gram.
E. sixteen atoms of helium weigh as much as four atoms of oxygen.

Items 351 - 354 are to be answered by reference to the following diagram of an atom of a particular element.



351. The valence of this element is
(2.10)

A. 1. **B.** 3. **C.** 5. **D.** 7. **E.** 9.

352. The atomic number of this element is
(2.10)

A. 2. **B.** 8. **C.** 16. **D.** 19. **E.** 21.

353. If the nucleus contains 21 neutrons, the atomic weight
(2.10) of this element is

A. 2. **B.** 40. **C.** 16. **D.** 19. **E.** 21.

354. This element can be characterized as
(2.10)

A. an inert gas. **B.** an oxidizing agent.
C. a reducing agent. **D.** a non-metal
E. none of these.

355. A substance is composed of elements "X" and "Y." Its
(2.10) formula is XY_2, indicating that

A. one atom of X combines with two atoms of Y.
B. one molecule of X combines with two molecules of Y.
C. two atoms of X combine with two atoms of Y.
D. two molecules of X combine with one molecule of Y.
E. two of the above are correct.

356. The element, oxygen, has an atomic weight of 16.00
(2.10) and an atomic number of 8. This means that in the nucleus of the oxygen atom there are

A. 8 protons and 8 neutrons.
B. 16 protons and 0 neutrons.
C. 16 neutrons and 0 protons.
D. 2 protons for every neutron.
E. 2 neutrons for every proton.

357. The atomic number of lead is 82, and its atomic weight
(2.10) is 207.21. This means that around the nucleus of the lead atom, there is an electron cloud composed of

A. 41 electrons. **B.** 207.21 electrons.
C. 82 electrons. **D.** 103.61 electrons.
E. 164 electrons.

358. If the valence of potassium in the formula $KMnO_4$ is
(2.10) +1, the valence of Mn in the formula is

A. +3. **B.** −3. **C.** +7. **D.** +8.
E. none of these.

Items 359 - 361 should be answered with the aid of the following paragraph.

Chemists using oxygen, atomic weight 16 and molecular weight 32, as standard, and the known weight under standard conditions of 1 liter of oxygen 1.429 gms., show that the volume occupied by 32 gms. of oxygen equals 32/1.429 or 22.4 liters. When nitrogen is used, the weight of 22.4 liters is 28 instead of 32. The two numbers, 28 and 32, must be the relative weights of an equal number of molecules of the gases. In numbers, the molecular weight of any gaseous element or compound is the same as the weight in grams of 22.4 liters of the gas.

359. The above paragraph makes particular use of the
(2.10)

A. Law of Definite Proportions.
B. Law of Avogadro.
C. Law of Conservation of Mass.
D. Law of Multiple Proportions.
E. Law of Gay Lussac.

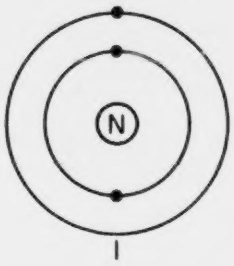
360. If the density of hydrogen is .08987 gm./liter under
(2.10) standard conditions, 22.4 liters of hydrogen should weigh

A. 1.008 gms. **B.** 2.016 gms. **C.** 4.064 gms.
D. 32/.08987 gms. **E.** none of these.

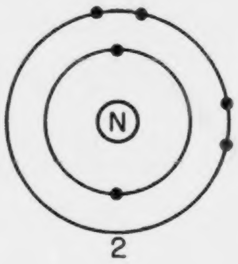
361. If the atomic weight of chlorine is 35.5, 22.4 liters
(2.10) under standard conditions

A. weigh 1.58 gm. **B.** weigh 35.5 gm.
C. weight 32 gm. **D.** weigh 71 gm.
E. weigh an amount which cannot be determined without knowing the weight of 1 liter.

Items 362 - 365 refer to the following diagrams.



1



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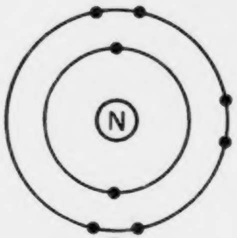

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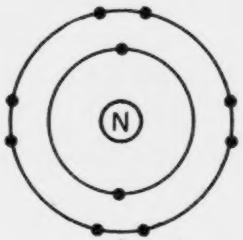


4

The above diagrams symbolize the electron configurations of the atoms of four different elements. Indicate which diagram would probably represent the element described in the statements. If none applies, mark space 5.

362. Oxidizes other substances readily.
(2.10)

363. Chemically inactive.
(2.10)

364. A very good reducing agent.
(2.10)

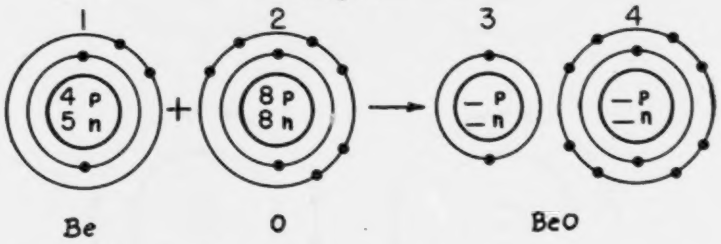
365. Shows a great tendency to form compounds by sharing
(2.10) electrons.

366. If an atom has 9 protons and 10 neutrons in its nucleus,
(2.10) and 9 planetary electrons, its atomic weight is probably

A. 9. **B.** 10. **C.** 18. **D.** 19. **E.** 28.

For items 367 - 371 refer to Diagram B.

Diagram - B



367. The atomic number of number 1 is
(2.10)

A. 2. **B.** 4. **C.** 5. **D.** 6. **E.** 9.

368. Number 4 in the diagram is
(2.10)

A. an atom of the free element. **B.** a compound.
C. a charged particle. **D.** a gas. **E.** a radical.

369. Number 3 in the diagram
(2.10)

A. has the same chemical properties as number 1.
B. is sharing electrons with number 4.
C. is an oxidizing agent. **D.** is in an ionized state.
E. has been reduced.

370. The number of protons and neutrons in number 4 is respectively
(2.10)

A. 9 p., 8 n. **B.** 8 p., 8 n. **C.** 8 p., 9 n.
D. 9 p., 9 n. **E.** 7 p., 9 n.

371. Number 1 in the diagram
(2.10)

A. acquires a negative valency in chemical reaction.
B. is an oxidizing agent.
C. decreases the valence of number 2 in chemical reaction.
D. is non-metallic in character.
E. is bi-valent in its compounds.

372. Certain elements have their electrons arranged in various orbits as follows:

Element a 2 : 8 (e.g., two electrons in first orbit and eight in the second).
b 2 : 8 : 8
c 2 : 8 : 18 : 8
d 2 : 8 : 18 : 18 : 8

The above elements

A. are good reducing agents.
B. belong to different groups.
C. acquire a valence of —1. **D.** are inert.
E. lose electrons in chemical reactions.

373. In chemical combination, a substance with atomic number 12 should acquire a valence of
(2.10)

A. —1. **B.** +1. **C.** —2. **D.** +2.
E. none of the above.

Items 374 - 388. After each item number on the answer sheet, blacken space

A. if the item is true of the element of electron structure 2-4.
B. if the item is true of the element of electron structure 2-8.
C. if the item is true of the element of electron structure 2-8-2.
D. if the item is true of the element of electron structure 2-8-7.
E. if the item is true of none of the above elements.

374. The valence of this element is +2.
(2.10)

375. This element is found in all carbohydrates.
(2.10)

376. This element is one of the metals.
(2.10)

377. This element forms an ionic compound with chlorine.
(2.10)

378. This element forms no compounds.
(2.10)

379. This element is the most active of the non-metals listed.
(2.10)

380. The atoms of this element gain electrons easily.
(2.10)

381. This element belongs in the same group in the periodic table as sodium.
(2.10)

382. The atom of this element has 12 electrons outside its nucleus.
(2.10)

383. This element belongs in the seventh group in the periodic table.
(2.10)

384. The atoms of this element form positive ions.
(2.10)

385. This element forms an ionic compound with sodium.
(2.10)

386. If we let X represent the symbol of this element, the formula of its chlorine compound is XCl_4.
(2.10)

387. If we let Y represent the symbol of this element, the formula of its sodium compound is Na_2Y.
(2.10)

388. If we let Z represent the symbol of this element, the formula of its oxygen compound is ZO.
(2.10)

For items 389 - 398, label the valence of each element indicated.
Example: the valence of calicum carbonate is 2.

389. The valence of hydrogen in H_2O is________.
(2.10)

390. The valence of copper in $CuSO_4$ is________.
(2.10)

391. The valence of magnesium in $MgSO_2$ is________.
(2.10)

392. The valence of zinc in ZnO is________.
(2.10)

393. The valence of OH in $Ca(OH)_2$ is________.
(2.10)

394. The valence of SO_4 in H_2SO_4 is________.
(2.10)

395. The valence of hydrogen in HCl is________.
(2.10)

396. The valence of sulphur in ZnS is________.
(2.10)

397. The valence of silver in $AgNO_3$ is________.
(2.10)

398. The valence of mercury in HgO is________.
(2.10)

Items 399 - 406. After each item number on the answer sheet, blacken space

A. if the item is true of an atom of orbital electron structure 2, 2.
B. if the item is true of an atom of orbital electron structure 2, 4.
C. if the item is true of an atom of orbital electron structure 2, 8.
D. if the item is true of an atom of orbital electron structure 2, 8, 7.
E. if the item is true of an atom of orbital electron structure 2, 8, 8, 1.

399. Of the elements listed, it is the most non-reactive.
(2.10)

400. Of the metals listed, it is the most reactive.
(2.10)

401. Of the non-metals listed, it is the most reactive.
(2.10)

402. It forms many compounds by electron-sharing.
(2.10)

403. It will form a negative monatomic ion.
(2.10)

404. It will form an ion of the type X++.
(2.10)

405. It most resembles argon in its properties.
(2.10)

406. It is in the same group in the periodic table as sodium.
(2.10)

407. Beryllium has an atomic number of 4. Its valence should be
(2.10)

A. 0. **B.** 1. **C.** −1. **D.** −2.
E. none of these.

Item 408 deleted.

409. An element with the electron structure 2, 8, 2
(2.10)

- **A.** has a negative electrovalence of two.
- **B.** has a positive electrovalence of two.
- **C.** has a negative electrovalence of six.
- **D.** forms only covalent compounds.
- **E.** is an inert gas.

410. Deduce the valence of the element silicon in the compounds H_2SiO_3. It is
(2.10)

A. +1. **B.** −1. **C.** −4. **D.** +4. **E.** +5.

411. Since one volume of hydrogen reacts with one volume of chlorine to produce two volumes of hydrogen chloride
(2.10)

- **A.** one molecule of each of the reacting elements combine to form one molecule of hydrogen chloride.
- **B.** each molecule of hydrogen chloride contains two atoms of hydrogen.
- **C.** the volume of a gas produced in any reaction is equal to the sum of the volumes of the gaseous reactants.
- **D.** the relation is an example of the law of combining weights.
- **E.** one molecule of hydrogen reacts with one molecule of chlorine to form two molecules of hydrogen chloride.

412. The atomic weight of carbon is 12 and the atomic number is 6. We believe that the nucleus of the carbon atom is made up of
(2.10)

- **A.** 6 protons and 6 neutrons.
- **B.** 8 protons and 8 neutrons.
- **C.** 16 protons and 8 electrons.
- **D.** 12 protons and 6 electrons.
- **E.** 8 protons and 6 neutrons.

413. The atomic weight of radium is 226 and its atomic number is 88. The nucleus of its atom is made up of
(2.10)

- **A.** 226 protons and 88 neutrons.
- **B.** 226 protons and 138 electrons.
- **C.** 226 protons and 138 positrons.
- **D.** 138 protons and 88 neutrons.
- **E.** 88 protons and 138 neutrons.

414. The atomic weight of oxygen is 16 and that of sulfur is 32. If a certain number of molecules of oxygen weigh 5 grams, how much will that number of sulfur atoms weigh?
(2.10)

A. 5 grams. **B.** 10 grams. **C.** 20 grams.
D. 1½ grams. **E.** 1¼ grams.

415. Radium has two electrons in its outer orbit. What compound would you expect it to form with chlorine which has 7 electrons in its outer orbit?
(2.10)

A. Ra_7Cl_2. **B.** Ra_2Cl_7. **C.** Ra_7Cl_6.
D. $RaCl_2$. **E.** Ra_2Cl.

416. Calculate the approximate relative weight of the molecule $NaHCO_3$, using the nearest integral values for the relative weights of the atoms. It is about
(2.10)

A. 52. **B.** 156. **C.** 108. **D.** 96. **E.** 84.

Items 417 - 419. A certain neutral atom is composed of 21 electrons, 21 protons, and 24 neutrons.

417. What is the approximate relative weight?
(2.10)

A. 21. **B.** 24. **C.** 45. **D.** 42. **E.** 66.

418. What is the atomic number?
(2.10)

A. 21. **B.** 24. **C.** 45. **D.** 42. **E.** 66.

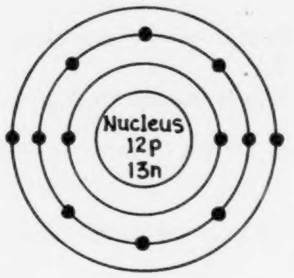
419. Of what element is it an isotope?
(1.10)

A. Calcium. **B.** Scandium. **C.** Chromium.
D. Neon. **E.** Zinc.

420. The electron structure of a certain neutral isotope is specified as follows: 2 electrons in K level, 8 electrons in L level, and 7 electrons in M level. Of what element is the above an isotope?
(2.10)

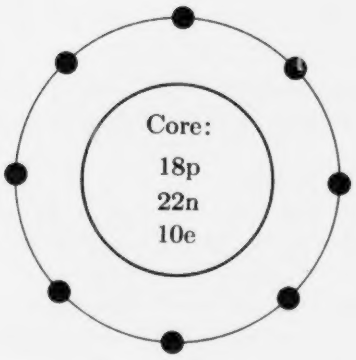
A. Chlorine. **B.** Oxygen. **C.** Fluorine.
D. Beryllium. **E.** Nitrogen.

421. A certain atom is symbolized as shown in the diagram below. What is the element whose isotope is represented?
(2.10)



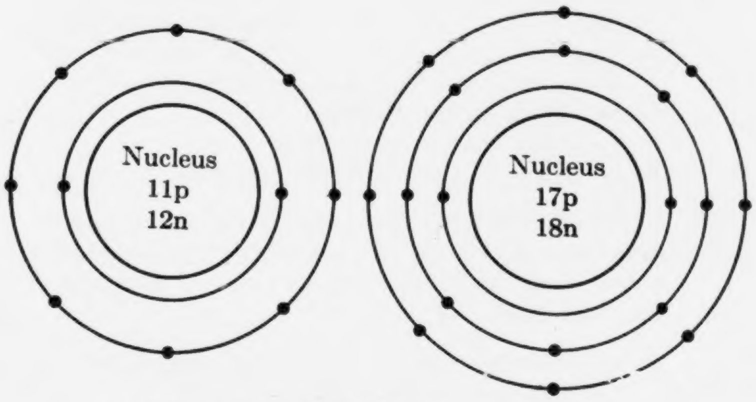
A. Manganese. **B.** Calcium. **C.** Carbon.
D. Aluminum. **E.** Magnesium.

422. What does the symbolization below represent?
(2.10)



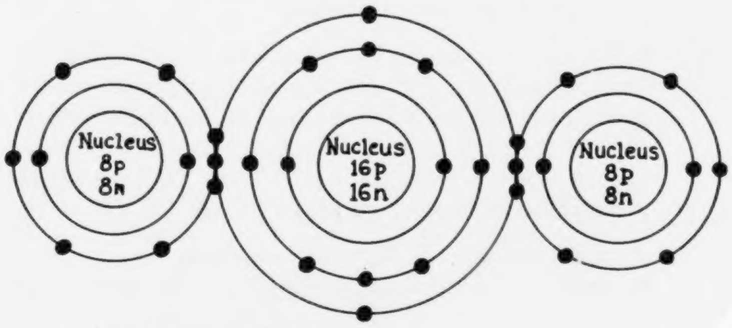
A. An argon atom. **B.** An argon ion.
C. A chlorine ion. **D.** A potassium ion.
E. A potassium atom.

423. (2.10) What compound is represented by the following symbolization?



A. Nitrogen bromide (NBr).
B. Lithium chloride (LiCl).
C. Sodium chloride (NaCl).
D. Sodium bromide (NaBr).
E. Potassium chloride (KCl).

424. (2.10) What compound is represented by the following symbolization?



A. Carbon dioxide (CO_2).
B. Sulfur dioxide (SO_2). **C.** Water (H_2O).
D. Hydrogen peroxide (H_2O_2).
E. Nitrogen dioxide (NO_2).

425. (2.10) Which best describes the forces holding two atoms together by a chemical bond?

A. The electrons act like tiny magnets and attract one another.
B. The atoms are always of opposite electrical charge and therefore attract one another.
C. The neutrons of the two atoms resonate with one another.
D. Electrons are shared, the electrons of each atom being attracted electrostatistically by both nuclei.
E. Each atom itself is a magnet and the south pole of one becomes attached to the north pole of the other by magnetic forces.

426. (2.10) A chemically active metal is an element whose atoms

A. gain a relatively large amount of energy in losing electrons.
B. gain a relatively small amount of energy in losing electrons.
C. lose a relatively large amount of energy in losing electrons.
D. lose a relatively small amount of energy in losing electrons.
E. can lose electrons without undergoing an energy change.

427. (2.10) According to Rydberg's formula, the lines in the emission spectrum of hydrogen are given by the equation

$$\frac{1}{\lambda} = R\,\frac{1}{m^2} - \frac{1}{n^2}$$

where m and n are integers. The quantity λ refers to a measurable characteristic of the line, since it represents

A. the width (thickness) of the line.
B. the length (height) of the line.
C. twice the minimum difference in path that can yield destructive interference between two parts of a single beam of light corresponding to the line.
D. twice the difference between the distance from the light source of the line as projected on a screen, measured once directly along a straight path, and again along the refracted path through the prism.
E. the distance of the line from one end of the spectrum.

428. The specific heats per gram of two chlorides of an element X are: (I) 0.152 and (II) 0.146. The specific heat of chlorine is 0.170 and that of element X is 0.115. What is the approximate atomic weight of element X? (The atomic weight of chlorine is 35.5.)

A. 17. **B.** 24. **C.** 37. **D.** 52.
E. None of these.

429. (2.10) Which of the formulas below represents compound II?

A. XCl. **B.** XCl_2. **C.** XCl_3. **D.** XCl_4.
E. None of these.

430. (2.10) Dalton states the circumstances under which a compound may be assumed to be binary, ternary, etc. What role do these statements play in Dalton's paper?

A. They constitute an indispensable part of Dalton's atomic theory.
B. They represent a working hypothesis leading to the calculation of atomic weights.
C. They are conclusions drawn from combining weight ratios of elements.
D. They are deductions from the atomic theory.
E. They are definitions of terms used in the atomic theory.

Suppose that four samples of different materials in powdered form are subjected to the following treatments:

When heated, *Sample A* melted at a relatively low temperature. When *Sample A* was dissolved in water, no reaction took place with the water, and the solution thus obtained would not conduct an electric current.

When an attempt was made to dissolve *Sample B* in carbon bisulfide, a solvent, a black residue remained undissolved. When the carbon bisulfide was poured off from the black residue and allowed to evaporate, a yellow residue remained.

When *Sample C* was heated it melted at a much higher temperature than Sample A. When Sample C was dissolved in water, no reaction was observed to take place, but the solution thus obtained did conduct an electric current.

Sample D was subjected to experimentation. Evidence was obtained which showed that all of the atoms of D have the same atomic number, although there was some variation in mass.

After each item number (items 431 - 437) on the answer sheet, blacken the *one* lettered space which designates the sample material to which the item correctly refers.

431. (2.20) When in solid form, positive and negative ions of this sample are held together by electrostatic forces.

432. (2.20) All of the atoms in the sample are atoms of the same element.

433. (2.20) This sample evidently consists of a non-ionic or covalent compound.

434. (2.20) This sample is evidently a mixture.

435. (2.20) This sample is evidently an ionic or electrovalent compound.

436. (2.20) The molecules of this compound evidently have little attraction for each other.

437. (2.20) The constituents of this sample are chemically uncombined.

438. (2.20) According to Rutherford, "Atoms of matter are not solid spheres, but empty structures consisting of extremely minute particles separated by relatively great distances." However, from cloud chamber observations, it was noted that fast-moving alpha particles passing through a gas may be slowed down and even stopped without ever hitting one of these minute particles in the center of the atoms of the gas! This can be explained by assuming that

A. Rutherford was not exactly correct, and that there is really a thin sort of matter within the atom as well as the minute particles.
B. the alpha particles passing through the gas lost their initial kinetic energy, and therefore their slowing down was not due to any action of the gas.
C. while the atoms of the gas may consist of empty structures containing only minute particles separated by relatively great distances, nevertheless there is probably a tenuous membrane stretched between the outer surfaces of the atoms which acts to slow down and stop the alpha particles.
D. the alpha particles contain great quantities of static electricity charge which react with the minute particles within the atoms of the gas to slow down and stop these particles.
E. powerful electric fields exist within the atoms of the gas itself, and that it is these fields which may slow down or stop the particles.

439. (2.20) The electron structure of the alkali metals indicates that

A. they should be very ready to take on a single electron for each atom.
B. in general, they should tend to form covalent compounds.
C. they should not be found in the free condition in nature.
D. lithium should be the most active of them.
E. all of them should be excellent oxidizing agents.

440. (2.20) The stability of an ionic compound such as potassium chloride is due to

A. the electrostatic force of attraction between the ions.
B. the difficulty in ionizing further an already ionized atom.
C. its high energy.
D. the fact that the formation of the compound is accomplished by the absorption of a considerable quantity of radiation or heat.
E. the fact that the energy lost in the formation of the negative ion far exceeds that gained in forming the positive ion.

441. (2.20) According to the Bohr theory of the atom, the inert gases are most accurately characterized as elements whose atoms have

A. the greatest possible number of electrons in the state with the highest principal quantum number occurring in the most stable configuration of the atom.
B. both very high ionization energy and very little ability to attract additional electrons.
C. no ability to lose electrons.
D. no ability to gain electrons.
E. no ability to gain or to lose electrons.

442. (2.20) In the periodic table of elements, there occurs immediately after each inert gas one of the chemically very active alkali metals. This sequence is due, according to the Bohr theory, to

A. a sudden increase in the nuclear charge, between the inert gas and the metal.
B. a sudden increase in atomic weight, owing to the high energy of the nuclei of metallic elements.
C. a sudden increase in the radius of the atom, leaving the outermost electron relatively loosely bound in the metallic atom.
D. a sudden change in the quantum numbers of the atom.
E. a sudden increase in the ionization energy, between the inert gas and the metal.

443. (2.20) It was realized during the nineteenth century that the characteristic physical and chemical properties of the metallic elements can be explained as due to a tendency of their atoms to become positively charged. This tendency is accounted for in Bohr's theory of the atom as a direct result of metallic atoms having

A. few electrons. **B.** many electrons.
C. relatively low ionization energy in their most stable states.
D. electrons in the outermost electron shell.
E. quantum numbers greater than those of non-metallic atoms.

444. (2.20) It is sometimes alleged that the occurrence of discrete bright-line spectra provides clear evidence that atoms have discrete energy levels. The existence of such line spectra was known, however, for the better part of a century before discrete energy levels were postulated for the atom. This situation is explained by the circumstance that

A. it was not known that there is a connection between radiation and energy.
B. it was not clear that the bright-line spectra are produced by processes occurring within atoms.
C. the conclusion does not follow unless it is assumed that atoms are divisible, and composed of electrified particles.

D. only Bohr's theory of atomic constitution made clear the role of discrete energy levels.

E. only on the basis of Planck's theory of radiation could a connection be expected between frequencies of radiation and energy states of atoms emitting the radiation.

445. (2.20) According to Newtonian mechancis, a body moving under the influence of an attraction to a fixed point, the attraction varying inversely with the square of the distance from the point, moves in a conic section with that point as a focus. Yet according to Bohr, the Rutherford model of the hydrogen atom does not appear to admit of stable orbits. Which of the following is the best explanation of this situation?

A. According to Bohr, Newtonian mechanics cannot be applied without qualification to atomic systems.

B. The nucleus of the hydrogen atom is in fact not a "fixed point," but rather moves under the influence of the force exerted upon it by the electron.

C. The force on the accelerating electron is not, according to Maxwell's electrodynamics, of the kind specified above which would give a stable orbit.

D. The behavior of an electron cannot, according to classical physics, be calculated solely from the force acting upon it; energy considerations must be taken into account, because of the radiation from an accelerating electron.

E. The proposition of Newtonian mechanics cited above does not exclude the possibility that the size of the orbit will continually diminish, so that the electron "spirals" in toward the nucleus.

446. (2.20) Which of the following is the best formulation of the *general problem* attacked by Bohr in his paper "On the Constitution of Atoms and Molecules"?

A. How is it possible to account for the events in space and time within the volume of an atom or molecule?

B. How can the emission of radiation by atoms in discrete quanta be accounted for by the laws of electricity and magnetism applied to the Rutherford nuclear atom?

C. At what points, and in what ways, should the received laws of mechanics and electrodynamics be modified so as to give a picture of atomic processes in accordance with experience?

D. Can the existence of distinct stationary states of the atom be reconciled with the phenomena of line spectra and with the Planck-Einstein theory of quantized radiation?

E. What information can the experimental studies of spectra provide concerning the structure of atomic and molecular systems?

447. (4.20) The principal reason for the existence of the problem attacked by Bohr was that

A. while radiation is emitted by atoms in a discrete fashion as far as frequency is concerned (line spectra), the emission nevertheless appears to be continuous in time.

B. the observed scattering of α particles, according to Rutherford, is compatible only with a nuclear model of the atom.

C. radiation phenomena indicate that, since atoms emit light, they must lose energy, and thus cannot exist in "stationary" states of constant energy; on the other hand, stationary states are required to account for the stability of the atom.

D. the Rutherford atom could not be stable if its electrons were at rest, nor, according to Maxwell's electrodynamics, if they were in motion; on the other hand, the Planck-Einstein theory of radiation involved concepts different from and contradictory to those of Maxwell's theory.

E. the fact that elements have characteristic spectra, exhibited by them both in the uncombined state and in compounds, indicates that these spectra are due to processes within individual atoms.

448. (2.20) Einstein's principal contribution to the quantum theory of light, in 1905, consisted in

A. the hypothesis that Planck's quantum postulate, with its basic equation $E = hf$, applies not only to black body radiation but to all emission and absorption phenomena.

B. the hypothesis that not only the emission and absorption, but the radiation itself is quantized into elements of magnitude $E = hf$, each of which is propagated intact.

C. the application of the idea of quantization to matter as well as to energy.

D. the extension of the notion of corpuscles of energy to all forms of radiation, especially to X-rays.

E. the application of the quantum hypothesis to the theory of the previously unexplained photoelectric effect.

Items 449 - 451 deleted.

452. (2.20) Cannizzaro apparently considers that the most valid criterion for the correctness of an atomic theory is

A. its degree of conformity to Avogadro's theory.

B. its degree of internal consistency.

C. that it provide a mechanical model, understandable at the gross level, for phenomena occurring at a level too minute to be directly observed.

D. its consistency with all known chemical and physical phenomena.

E. its degree of simplicity.

453. (2.20) How may the statement, "The atomic weight of nitrogen is 14," be interpreted in Cannizzaro's sense?

A. An atom of nitrogen weighs 14 units.

B. In a compound of nitrogen and hydrogen, the nitrogen has 14 times the weight of the hydrogen.

C. A liter of nitrogen has 14 times the weight of a liter of hydrogen.

D. No smaller weight of nitrogen than 14 grams is ever found in a molecular weight (in grams) of any compound of nitrogen.

E. A gram of nitrogen contains 14 times as many atoms as a gram of hydrogen.

454. (2.20) Suppose 2 liters of a gaseous element X combine with 3 liters of a gaseous element Y to form 3 liters of a gaseous compound. If one assumes that the separate and independent particles of elementary gases are atoms, what conclusion necessarily follows?

A. Gases X and Y do not have the same number of atoms in equal volumes.

B. There are more atoms of gas X than gas Y per liter.

C. There are fewer atoms of gas X than gas Y per liter.

D. Equal volumes of gases contain the same number of atoms.

E. None of these is a necessary conclusion.

455. (2.20) Under the assumption that the separate and independent particles of gas may be divisible and that equal volumes of X, Y, and the compound contain equal numbers of particles, one may conclude that the particles of gas X consist of

A. two atoms. **B.** some even number of atoms.
C. a number of atoms which is a multiple of 3.
D. a number of atoms which is a multiple of 6.
E. any number of atoms as far as this single datum is concerned.

456. (2.20) If equal volumes of gases contain equal numbers of particles, then a possible formula for the compound referred to in item 455 is

A. XY. **B.** XY_2. **C.** X_2Y_4. **D.** X_3Y_2. **E.** X_3Y_3.

Items 457 - 461 refer to various processes related to atomic or molecular structure. For each item select from the key the changes involved in the process.

KEY

A. Only electron changes between atoms.
B. Alteration in the number of protons and neutrons.
C. Alteration only in the number of neutrons.
D. Changes in arrangement of all particles in the atom.
E. No change in relation to the number of electrons, protons, or neutrons in the atom.

457. (2.40) Differences between two isotopes of the same element.

458. (2.40) Electrolytic conduction. **459.** (2.40) Fractional distillation.

460. (2.40) Fission.

461. (2.40) Rubbing a rubber rod with a piece of wool.

Items 462 and 463 refer to the following data. The molecule of a certain compound is composed of carbon and hydrogen atoms. The weight of the molecule is 58 times the weight of the hydrogen atom. By an analysis it is shown that about 5/29 of the weight of the molecule is due to hydrogen, the remainder being due to carbon. (atomic weights: $H = 1$, $C = 12$).

462. (3.00) How many hydrogen atoms are in the molecule of the compound?

A. 10. **B.** 8. **C.** 6. **D.** 5. **E.** 4.

463. (3.00) How many carbon atoms are in the molecule of the compound?

A. 1. **B.** 2. **C.** 3. **D.** 4. **E.** 5.

464. (3.00) An electric spark is passed through a mixture containing 16 grams of oxygen gas and 4 grams of hydrogen gas. After the explosion, there is in the container

A. 16 grams of water and 4 grams of hydrogen.
B. 8 grams of water and 12 grams of oxygen.
C. 6 grams of water and 14 grams of oxygen.
D. 20 grams of water.
E. 18 grams of water and 2 grams of hydrogen.

465. (3.00) A certain metal will liberate hydrogen from dilute acids although it does so from water only when the metal is strongly heated and the water is in the form of steam. With relation to the activity series of the metals, this metal

A. is high in the series.
B. probably stands close to and below hydrogen.
C. probably stands close to and above hydrogen.
D. is below mercury and copper. **E.** is below silver.

466. (3.00)
a. A molecule of nitrogen gas is heavier than a molecule of water vapor.
b. A molecule of water vapor is heavier than a molecule of oxygen gas.
c. A molecule of oxygen gas is heavier than a molecule of neon gas.

Which of the following choices lists only the correct statements of those given?

A. a. **B.** b. **C.** c. **D.** a and b. **E.** a and c.

467. (3.00)
a. One molecule of pure siderite, $FeCO_3$ is heavier than one molecule of pure hematite, Fe_2O_3.
b. 50 pounds of siderite contains more molecules than does 50 pounds of hematite.
c. One molecule of siderite contains a greater percentage of iron than does one molecule of hematite.

Which of the following choices lists only the correct statements of those given?

A. a. **B.** b. **C.** c. **D.** a and b. **E.** a and c.

468. (3.00) The atomic weight of sodium is 23. When we start with hydrogen and arrange the elements in the order of their increasing atomic numbers, sodium is 11th on the list. From this we may determine the number of neutrons in the nucleus of the sodium atom to be

A. 12. **B.** 11. **C.** 34.
D. equal to the total number of electrons in the orbits about the nucleus.
E. equal to the electrons in the outermost orbit or energy level.

Items 469 - 470 are to be answered in accordance with the following key. For each item select from the key the one choice that names only the correct inference or inferences of those given.

KEY

A. a. **B.** b. **C.** c. **D.** a and b. **E.** a and c.

469. (3.00) Knowing the atomic weights, $Fe = 55$, $C = 12$, $O = 16$, one can infer that
a. a molecule of siderite, $FeCO_3$, is heavier than a molecule of hematite, Fe_2O_3.
b. 50 pounds of siderite contains more molecules than does 50 pounds of hematite.
c. one molecule of siderite contains a greater percentage of iron than does one molecule of hematite.

470. (3.00) Knowing that the efficiency of a heat engine equals $(T_1 - T_2) — T_1$, one can infer that the maximum efficiency of a mechanically-perfect heat engine may be increased by

a. lowering the exhaust temperature while maintaining the intake temperature unchanged.
b. raising the exhaust temperature and lowering the intake temperature.
c. increasing the amount of heat taken in from the surroundings while maintaining the intake and exhaust temperatures unchanged.

471. The weight of a molecule of oxygen is 16 times as much
(3.00) as the weight of a molecule of hydrogen. One balloon is to be inflated with 2 liters of oxygen and another balloon of the same size with 2 liters of hydrogen measured under standard conditions. If both are kept at the same temperature, the pressure of the oxygen in the first balloon necessary to attain the same volume as the second balloon will be

A. sixteen times as great as in the second.
B. one-sixteenth that in the second.
C. equal to that in the second.
D. four times as great as in the second.
E. one-fourth as great as in the second.

472. It is found that 2.00 liters of a gas at standard condi-
(3.00) tions weigh 4.50 gm. The gram-molecular weight of the gas is

A. 4.50 gm. **B.** 2.25 gm. **C.** 50.4 gm.
D. 25.2 gm. **E.** none of these.

473. Given two elements X and Y such that the atomic num-
(3.00) ber of X is 13 and Y is 8, what would be the resulting compound if both X and Y exert their usual valence?

A. XY. **B.** X_2Y_3. **C.** X_3Y_2. **D.** X_3Y.
E. X and Y would not combine.

474. If an atom of lithium containing 3 protons and 4 neu-
(3.00) trons unites with an atom of fluorine containing 9 protons and 10 neutrons, the ion of lithium in the compound LiF will have

A. 2 protons. **B.** 3 protons. **C.** 4 protons.
D. 12 protons. **E.** none of these.

475. If an atom containing 3 protons and 4 neutrons com-
(3.00) bines with a second atom with 9 protons and 10 neutrons, the ion of the second atom in the compound will have

A. 12 protons. **B.** 4 protons. **C.** 10 protons.
D. 9 protons. **E.** none of these.

476. Manganese will form the following compounds with
(3.00) oxygen, MnO, Mn_2O_3, MnO_3 and Mn_2O_7. The valence which is *not* represented by manganese in these compounds is

A. 2. **B.** 3. **C.** 4. **D.** 5. **E.** 6.

477. Dalton's Atomic Theory offers a reasonably satisfactory
(3.00) explanation for *one* of the following statements. You are to determine which one this is.

A. When hydrogen combines with oxygen, a large amount of energy is liberated.
B. Forces holding the atoms together in a molecule of nitroglycerine are so small that the compound is explosive.
C. The weight of carbon dioxide produced by burning a given amount of carbon can be accurately predicted.
D. Hydrogen atoms combine with oxygen atoms more readily than with chlorine atoms.
E. Four atoms of hydrogen combine with one atom of carbon, but two atoms of hydrogen combine with one atom of oxygen.

478. Analysis of ammonia, a compound of nitrogen and
(3.00) hydrogen, shows that 28 grams of nitrogen are combined *with every* 6 grams of hydrogen. Each nitrogen atom is, approximately, 14 times as heavy as a hydrogen atom. Therefore, the ratio of nitrogen to hydrogen atoms in ammonia is

A. 14 to 3. **B.** 1 to 3. **C.** 3 to 1.
D. 1 to 2. **E.** 2 to 1.

Items 479 - 489. The better known metallic elements are arranged at the right in the "activity series." After each item number on the answer sheet, blacken space

A. If the item is true of sodium (Na).
B. if the item is true of aluminum (Al).
C. if the item is true of iron (Fe).
D. if the item is true of hydrogen (H).
E. if the item is true of silver (Ag).

K
Na
Ca
Mg
Al
Zn
Fe
Sn
H
Cu
Hg
Ag
Au

479. This element displaces only gold (Au) from its com-
(3.00) pounds.

480. This element releases hydrogen rapidly even from cold
(3.00) water.

481. This is a "noble" metal.
(3.00)

482. Calcium (Ca) would displace this metal from its salts,
(3.00) but zinc (Zn) would not.

483. This element has the greatest tendency of those listed
(3.00) to lose electrons and to become a positive ion.

484. The ions of this element have the greatest tendency of
(3.00) those listed to take electrons and thereby turn back into the metal.

485. This element would be more likely than any other to
(3.00) be found in nature in elementary form.

486. The ions of this element can take electrons from tin
(3.00) (Sn) but not from mercury (Hg).

487. When mixed in powdered form with iron oxide and
(3.00) ignited (the thermite process), this metal replaces the iron in the oxide.

488. This element releases hydrogen from acids, but less
(3.00) readily than any of the other metals listed above.

489. This metal will not displace hydrogen from HCl.
(3.00)

490. An element with the electronic structure 2, 8, 1 will
(3.00) react with an element the electronic structure of which is 2, 8, 7 to form a substance which, at room temperature is

A. a gas. **B.** a liquid. **C.** a crystalline solid.
D. an acid. **E.** a covalent compound.

491. Al_2O_3 and CCl_4 are the correct formulae of the oxide
(3.00) of aluminum and the chloride of carbon. The formula of the compound aluminum carbide is therefore

A. Al_4C_2. **B.** Al_3C_4. **C.** AlC. **D.** Al_4C_3.
E. none of these formulae.

492. Two energy levels with an atom differ by 3×10^{-12}
(3.00) erg. Assuming Planck's constant to be 6×10^{-27} erg-sec, the wavelength of the radiation emitted when an electron jumps from one of these levels to the other is

A. 3×10^{-12} cm. **B.** 1.67×10^{-4} cm.
C. 5×10^{-4} cm. **D.** 16,700 A. **E.** 6000 A.

493. (3.00) The relative abundance of the two rubidium isotopes of atomic weights 85 and 87 are 75% and 25%, respectively. The average atomic weight of rubidium is

A. 85. **B.** 85.5. **C.** 86. **D.** 86.5. **E.** 87.

494. (3.00) The atomic weight of nitrogen is 14 and that of oxygen is 16. Which of the following are *not* true of the compound N_2O_5?

A. There are 108 grams in one mole.
B. There are 2 moles in 216 grams.
C. There are 10 gram atoms of oxygen in 108 grams.
D. Fifty-four grams contain one gram atom of nitrogen.
E. There are about 4.2×10^{-24} atoms of all kinds in 108 grams.

495. (3.00) The atomic weight of Na (sodium) is 23 and that of oxygen is 16. A compound of sodium and oxygen can be made which is 41.8% Na. Its formula could be which of the following?

A. Na_3O. **B.** Na_2O. **C.** Na_2O_2. **D.** NaO_2.
E. NaO_3.

Items 496 - 497. Four, and only four, of the following form a consistent set of statements which might characterize a certain element Q.

1. One atom of the element combines with two chlorine atoms to form an electrovalent compound.
2. The atoms of the element's isotopes contain not less than 20 neutrons.
3. In the normal atoms of the element, 2 electrons are in the K level, 8 electrons in the L level, and 2 electrons in the M level.
4. The atoms of the element contain 20 protons in the nucleus.
5. The relative weight of the element is practically 40.

496. (3.00) The statement which is inconsistent with the others is

A. 1. **B.** 2. **C.** 3. **D.** 4. **E.** 5.

497. (3.00) The set of four consistent statements characterizes what elements?

A Calcium. **B.** Germanium. **C.** Sodium.
D. Potassium. **E.** Magnesium.

498. (3.00) Which one of the following choices involves the greatest number of atoms concerned?

A. 12 pounds of carbon. **B.** 100 pounds of lead.
C. 100 pounds of iron. **D.** 20 pounds of silicon.
E. 20 pounds of neon.

499. (3.00) Suppose that f_1 and f_2 represent the frequencies of two lines in the spectrum of hydrogen. Light of frequency $f_1 + f_2$

A. must also be present in the spectrum of hydrogen.
B. must be present in the spectrum of hydrogen, provided that the higher energy level involved in the emission of one of the lines is identical with the lower level involved in the emission of the other.
C. must be present in the spectrum of hydrogen, provided that the higher energy levels involved in the emission of f_1 and f_2 are identical but not otherwise.
D. must be present in the spectrum of hydrogen, provided that either the higher or the lower energy levels involved in the emission of f_1 and f_2 are identical.
E. need not be present in the spectrum of hydrogen under any of the above circumstances.

500. (3.00) Millikan's measurements of the potential difference V, in his photoelectric experiments, give results which require to be corrected, since they are affected by the contact potential difference between the two electrodes. When this correction has been made, if the resulting graph of V against f does indeed satisfy the equation

$$\frac{1}{2}\,mv^2 = Ve = hf - p,$$

the value of f where the graph intersects the f-axis (i.e., where V = O) should enable one to determine

A. the frequency of a line in the absorption spectrum of the metal displaying the photoelectric effect.
B. the highest frequency of light for which the metal in question displays the photoelectric effect.
C. Planck's constant.
D. the minimum work required to remove an electron from the metal under investigation.
E. under what conditions a photoelectric effect can be produced without applying a potential difference between the electrodes, and when such a potential difference is required.

501. (3.00) If a certain metal gives a photoelectric effect under visible light of a certain color C, one should expect the effect to occur, for that metal,

A. under light of any color on the red side of C in the spectrum.
B. under light of any color on the violet side of C in the spectrum.
C. under light of any color whose wave length is an integral multiple of that of C.
D. under light of any color whose frequency is an integral multiple of that of C.
E. under any kind of light whose energy quanta are integral multiples of h.

502. (3.00) In Rutherford's calculations, he assumes that the atom with which an α particle interacts is at rest during the interaction. The mass of a gold atom is approximately 50 times the mass of an α particle. If a single α particle, moving at 2×10^9 cm./sec., meets a gold atom and is deflected through 180°, emerging at the same speed with which it entered, and if the total momentum of the particle and the atom is the same before and after the encounter, the atom must have acquired a speed of

A. zero. **B.** 2×10^{-2} cm./sec. **C.** 1 cm./sec.
D. 8×10^7 cm./sec. **E.** 5×10^8 cm./sec.

503. (2.00) In the light of the considerations given in the preceding item, which of the following remarks is justified concerning the status of Rutherford's assumption that the atoms are stationary?

A. In the experiments cited by Rutherford, the speeds of the α particles were only 1.7 and 1.8×10^9 cm./sec., so that the result of the calculation in the preceding item is not directly relevant.
B. Rutherford is entitled to assume that the forces between the atoms, which give the metal its solidity, prevent any one atom from acquiring a high speed; the momentum imparted by the encounter is therefore not carried by a single atom, but shared among many.
C. The considerations given in the preceding item bear out Rutherford's assumption that the velocity imparted to the atom is either zero or insignificant.

D. The considerations given in the preceding item are not easily reconciled with Rutherford's assumption; hence, since that assumption is required to derive his results (which accord with experiment), some modification of classical mechanics—possibly giving up the law of the conservation of momentum—is indicated.

E. Rutherford's assumption is not affected by the considerations given, since that assumption has the status of a working hypothesis which is justified as long as it leads to results borne out by experiment.

504. Let A and B be positive point charges, of magnitude Q_A and Q_B respectively. Suppose that B is held fixed in position, while A is projected directly toward B. The distance R between A and B, when A is projected, is so great that the electric repulsion $\frac{Q_AQ_B}{R^2}$ and the potential energy $\frac{Q_AQ_B}{R}$ are both negligible. If M_A is the mass of A, M_B the mass of B, and v_o the speed with which A is projected, the total energy of the system consisting of these two charges, at the instant of projection, is

A. $\frac{1}{2}\ M_Av_o^2$. **B.** $\frac{1}{2}\ (M_A + M_B)v_o^2$.
C. $\frac{1}{4}\ (M_A + M_B)v_o^2$.
D. $\frac{1}{2}\ M_Av_o^2 - 2\ \frac{Q_AQ_B}{R}$. **E.** $\frac{2Q_AQ_B}{M_Av_o^2}$.

505. (3.00) If at some later time the distance between the two charges is x, and if A is then moving with speed v, the total energy of the system at that time will be

A. $\frac{1}{2}\ M_Av^2$. **B.** $\frac{1}{2}\ M_Av^2 + \frac{Q_AQ_B}{x}$.
C. $\frac{1}{2}\ M_Av^2 + \frac{Q_AQ_B}{R}$.
D. $\frac{1}{2}\ (M_A + M_B)\ (v^2 - v_o^2) + 2Q_AQ_B\ (\frac{1}{R} - \frac{1}{4})$.
E. $\frac{2Q_AQ_B}{M_Av_o^2}$.

506. (3.00) If the distance between A and B at the time when A comes instantaneously to rest, reversing its direction of motion, is d, then the principle of the conservation of energy implies (assuming that no energy losses have occurred through radiation, friction, or other processes) the equation

A. $\frac{1}{2}\ M_Av_o^2 = O$. **B.** $\frac{1}{2}\ M_Av_o^2 = \frac{Q_AQ_B}{d}$.
C. $\frac{1}{2}\ M_Av_o^2 = \frac{Q_AQ_B}{R}$.
D. $\frac{1}{2}\ (M_A + M_B)v_o^2 = \frac{2Q_AQ_B}{d}$.
E. $\frac{1}{2}\ (M_A + M_B)v_o^2 = \frac{2Q_AQ_B}{M_Av_o^2}$.

507. (2.20) The considerations involved in the preceding three items sufficed to enable Rutherford to determine

A. the radius of an atom. **B.** the charge of an atom.
C. the probability of an α particle experiencing a given deflection ϕ in traversing a metal foil.
D. the closest distance from the center of an atom of given nuclear charge that an α particle of given speed can reach.
E. the deflection ϕ experienced by an α particle of given speed v_o which travels initially so as to pass an atomic nucleus of given charge Q_B at a distance d.

508. (3.00) When a narrow beam of cathode rays is deflected in a magnetic field, it spreads out, according to Thomson, into a broad fan-shaped luminosity in the gas; thus the rays are not all equally deflected. The most probable explanation of this effect is that

A. the magnetic field is not accurately homogeneous, but is stronger in some places than in others.
B. the magnetic field is not uniform in direction.
C. the mass and charge are not the same for all the particles in the beam, only the ratio m/e being constant.
D. the particles do not all have the same velocity.
E. minute variations in the density of the gas in the tube produce a dispersion of the rays in the magnetic field.

Items 509 - 519. Gaseous element X has a specific gravity (relative to oxygen) of 0.94; gaseous element Y has a specific gravity of 3.75. They form three gaseous compounds with each other, the combining weights and specific gravities being tabulated below.

	Combining weights	Specific gravities
Compound I	1 gm X + 2 gm Y	2.8
Compound II	1 gm X + 4 gm Y	1.2
Compound III	1 gm X + 8 gm Y	4.2

(The atomic weight of oxygen is 16.0; its molecule contains two atoms.)

509. (3.00) Which of the compounds would be considered as binary according to Dalton's method for determining atomic weight?

A. Compound I. **B.** Compound II.
C. Compound III.
D. All of these are equally likely to be binary.
E. None of these could be binary, since no ratio is 1 : 1.

510. (3.00) Using Dalton's method, the atomic weight of element Y is calculated to be

A. two. **B.** twice that of element X. **C.** three.
D. four times that of element X. **E.** eight.

511. (2.00) How would the application of Cannizzaro's method for determining the atomic weight of element Y constitute an improvement over Dalton's method?

A. By identifying the spatially separate particles of element Y as molecules instead of atoms.
B. By postulating that the molecules of element Y consist of two atoms.
C. By utilizing molecular weights calculated from the specific gravities listed.
D. By defining atomic weights in terms of oxygen as a standard instead of hydrogen.
E. By yielding absolute atomic weights rather than merely relative atomic weights.

512. (3.00) What are the relative volumes of the gases involved in the formation of compound I?

A. 1 of X and 1 of Y yield 2 of compound I.
B. 1 of X and 2 of Y yield 2 of compound I.
C. 2 of X and 1 of Y yield 2 of compound I.
D. 1 of X and 2 of Y yield 3 of compound I.
E. The data give no information on this matter.

513. Division of the molecule of element Y must have occurred in the formation of
(3.00)

A. compound I only. **B.** compound II only.
C. compounds I and II, but not III.
D. compound III only.
E. none of these compounds.

514. Division of the product molecule (in Avogadro's sense) occurs in the formation of
(3.00)

A. compound I only. **B.** compound II only.
C. compound III only. **D.** all three compounds.
E. none of the compounds.

515. The specific gravity of element Y indicates that the atomic weight of element Y
(3.00)

A. must be 120.
B. must be 120/n, where n is a small whole number.
C. must be 60.
D. must be 60/n, where n is a small whole number.
E. cannot exceed 3.75.

516. The molecule of element Y is, most likely, composed of
(3.00)

A. one atom. **B.** two atoms. **C.** three atoms.
D. four atoms. **E.** six atoms.

517. The specific gravity of element X, together with the data given for its compounds, indicates that, of the following, the most probable atomic weight of element X is
(3.00)

A. 7.5. **B.** 15. **C.** 30. **D.** 45. **E.** 94.

518. How can the approximate atomic weight of element X be determined with more certainty?
(2.00)

A. By measuring the combining volumes of elements X and Y.
B. By measuring the molecular weights of the compounds formed.
C. By measuring the combining weight of element X with oxygen.
D. By measuring the combining weights and specific gravities more precisely.
E. By obtaining comparable data for additional compounds of element X.

519. What is the most probable formula for compound I?
(3.00)

A. XY. **B.** XY_2. **C.** X_2Y. **D.** X_2Y_2. **E.** X_4Y_2.

Items 520 - 525. Sulfur forms four compounds with oxygen. The composition of each, expressed in gram of oxygen per gram of sulfur, and their specific gravities in the vapor state, relative to oxygen, are shown in the table.

	Composition	*Specific Gravity*
Compound I	0.75	3.5
Compound II	1.00	2.0
Compound III	1.50	2.5
Compound IV	1.75	5.5

520. Suppose Compound III has been assumed as binary. Then Compound II would be formulated as
(3.00)

A. S_2O_3. **B.** SO_2. **C.** SO_3. **D.** S_3O_2.
E. No formula could be derived under this assumption.

521. If Compound III were binary, the atomic weight of sulfur (relative to oxygen taken as 16) is nearest
(3.00)

A. 11. **B.** 16. **C.** 32. **D.** 48. **E.** 64.

522. What is the chief defect of Dalton's method for determining atomic weight?
(2.00)

A. The experimental errors are excessive.
B. Several atomic weights can be derived for the same element, depending on the molecular constitution chosen.
C. No reliable method is available for determining the weight ratios of different elements in the compound.
D. There is no reliable standard for the atomic weight scale.
E. Only relative atomic weights are possible.

523. The present-day values for the atomic weights of sulfur and oxygen are 32 and 16, respectively. What is, therefore, the simplest formula for compound IV?
(3.00)

A. SO. **B.** SO_2. **C.** SO_3. **D.** S_2O_3. **E.** S_2O_7.

524. In order to calculate the molecular weight of Compound IV on the scale in which the molecular weight of oxygen is 32, what information is required other than that given before item 520?
(3.00)

A. The specific gravity of oxygen.
B. The molecular weight of hydrogen.
C. The per cent composition of compound IV.
D. The atomic weight of oxygen.
E. No other information is required.

525. The calculation of molecular weight referred to above is based on the assumption that
(2.00)

A. all molecules of the same substance are alike.
B. one molecular weight in grams occupies one liter.
C. equal weights of all gases contain the same number of molecules.
D. the molecular weights of gases are proportional to their specific gravities.
E. equal volumes of solids, liquids, and gases contain the same number of molecules at the same temperature and pressure.

526. One liter of nitrogen combines with three liters of hydrogen to form two liters of ammonia. Nitrogen is 14 times as dense as hydrogen. How dense is ammonia?
(3.00)

A. 7 times as dense as hydrogen.
B. 8½ times as dense as hydrogen.
C. 17 times as dense as hydrogen.
D. 28 times as dense as hydrogen.
E. The answer cannot be obtained from the information given.

527. Dalton considered ammonia to be a binary compound because
(1.10)

A. its composition showed the presence of only nitrogen and hydrogen.
A. its molecule consisted of one atom of nitrogen and one atom of hydrogen.
C. he knew of no other compound containing only nitrogen and hydrogen.
D. the simplicity of weight ratios of hydrogen and nitrogen in ammonia could only be attributed to a molecule containing only two atoms.

528. If ammonia is binary, a consideration of the combining volumes of hydrogen and nitrogen (see item 526) would lead Dalton to the conclusion that
(3.00)

A. there are twice as many atoms in a liter of nitrogen as there are compound atoms of ammonia in a liter of ammonia.

- **B.** the number of atoms in a liter of gas is independent of the nature of the gas.
- **C.** the number of atoms in equal volumes of gases is inversely proportional to the relative weights of the atoms.
- **D.** two liters of ammonia have the same weight as one liter of nitrogen plus three liters of hydrogen.
- **E.** atoms of nitrogen are divisible.

529. (3.00) Avogadro would conclude from the data in item 526 that

- **A.** the molecules of nitrogen and hydrogen are divisible.
- **B.** the molecules of nitrogen are divisible, but not those of hydrogen.
- **C.** the molecules of hydrogen are divisible, but not those of nitrogen.
- **D.** the atoms of nitrogen are divisible.
- **E.** one atom of nitrogen combines with three atoms of hydrogen to form two molecules of ammonia.

Items 530 - 536. For each of the items, mark

- **A.** if it should be regarded as *supported* by the agreement of Rutherford's calculations with experimental data.
- **B.** if it is a presupposition of Rutherford's calculations which is *in no need of support,* since its validity is guaranteed by purely mathematical considerations.
- **C.** if it is presupposed either in Rutherford's calculations or in his general considerations concerning the structure of atoms, and is *in no need of support from Rutherford* because it is implied by physical considerations other than Rutherford's.
- **D.** if it is implied by other considerations than Rutherford's and must be regarded as true, but is *hard to reconcile with Rutherford's results,* and so points the way to further investigation.
- **E.** if it is a presupposition of Rutherford's calculations which *cannot be regarded as supported* by any arguments set forth by Rutherford or by other considerations understood at the time, but is rather a pure assumption which remains for further testing.

530. (4.20) The scattering of particles by thin foils of metal is produced in such a way that the observed deflection of any particle through a large angle must have been produced at a single encounter with an atom.

531. (4.20) An atom must contain negative charges in the form of "electrons," or light particles, arranged within the atomic radius of 10^{-8} cm. in such a way as to form a stable configuration.

532. (4.20) Atoms are composed of electrically charged particles, the negative charges occurring in corpuscles of very small mass and the atom as a whole normally being electrically neutral.

533. (4.20) The mass and a large part of the positive or negative charge in an atom is concentrated in a very minute volume at its center.

534. (4.20) The atoms in a metal foil can be regarded as practically fixed in position during an interaction with an α particle.

535. (4.20) A body whose acceleration varies inversely as the square of its distance from a point and is always directed away from that point, moves in a hyperbola with that point as a focus.

536. (4.20) The force between two point charges at distances of the order of magnitude of 10^{-12} cm. or more, is correctly predicted by Coulomb's Law.

537. (4.10) Thomson and Rutherford, in discussing the constitution of atoms, assume that the elements out of which atoms are built are charged particles. Which of the following does *not* constitute part of the evidence for this view?

- **A.** Coulomb's Law for the electrostatic force between point charges.
- **B.** The fact that all conductors contain charges that are free to move.
- **C.** The fact that the properties of dielectrics are accounted for by the hypothesis of their "polarization" in electric fields.
- **D.** The ejection of α and β particles in radioactive decay.
- **E.** The identity of the properties of cathode rays derived from various sources.

Items 538 - 543. By placing a magnet in a suitable position between the cathode and the cylinders, Perrin caused the cathode rays to be deflected away from the cylinders; in this case no charge was produced. Thomson placed the cylinders so that the rays fell upon them only when deflected by a magnet; he detected a significant charge when the rays fell upon the cylinders, not otherwise.

For each of the items, mark

- **A.** if it is a direct consequence of Thomson's experiment, but not of Perrin's.
- **B.** if it is a direct consequence of Perrin's experiment, as well as of Thomson's.
- **C.** if it is disproved by Thomson's experiment, but not by Perrin's.
- **D.** if it is disproved by Perrin's experiment, as well as by Thomson's.
- **E.** if it is neither proved nor disproved by either experiment.

538. (4.10) The cathode rays consist of moving charged particles.

539. (4.10) If the cathode rays consist of charged particles, the particles bear a negative charge.

540. (4.10) Negative charges flow from the cathode in a cathode ray tube.

541. (4.10) If cathode rays are accompanied by a discharge of electricity from the cathode, the motion of electricity through the tube may yet be independent of the motion of the cathode rays themselves.

542. (4.10) There exists in a cathode ray tube, when the rays occur, a flow of electricity, and the path of the electricity is always the same as the path of the rays.

543. (4.10) The small electric current which flows through a cathode ray tube may be due entirely to a motion of positive charges from anode to cathode, and so may be quite distinct from the cathode rays.

Items 544 - 547 refer to the following equation where the exponents show the electrical state.

$$Zn^{\circ} + 2H^{+1}Br^{-1} \rightarrow Zn^{+2}Br^{(-1)}{}_2 + H_2{}^{\circ}$$

For each item select from the key the most appropriate response.

KEY

A. Statement true—reason supports it.
B. Statement true—reason false.
C. Statement false—reason supports the contrary.
D. Statement false—reason immaterial.

544. (4.20) Br was reduced because its valence increased in the reaction.

545. (4.20) The reaction was a neutralization because H_2O was formed.

546. (4.20) Zn was oxidized in the reaction because it lost electrons.

547. (4.20) The hydrogen was reduced because its valence was increased.

548. (4.20) The Pauli "exclusion principle," which asserts that no two electrons in an atom can agree in the values of all four of their quantum numbers, provides the theoretical basis for understanding

A. the relation of spectral-line series to atomic structure in atoms more complex than that of hydrogen.
B. the forces which hold the components of molecules together.
C. the relation of the properties of an atom connected with radiation to its chemical behavior.
D. the periodic structure of electron shells.
E. the possibility of Bohr's "stationary states."

549. (4.20) The failure of classical physics, applied to the Rutherford atom model, to account for the stability of the atom leads Bohr to attempt to answer the question:

A. Do there exist other processes which classical physics is unable to explain?
B. How can we explain the existence of stable atoms, in which electrons circulate around the nucleus but do not produce radiation?
C. How can we determine which of the imaginable orbits of the electron in the atom are in fact stable (classical physics to the contrary notwithstanding)?
D. If electrons circulating about nuclei do not emit radiation, then what becomes of the energy which, according to classical physics, should be emitted in this fashion?
E. If the light emitted by atoms does not constitute electromagnetic radiation, then what sort of process is it?

550. (4.20) The importance for Bohr's argument of the fact that the quantities which characterize the Rutherford atom (charge of the electron, 4.8×10^{-10} e.s.u.; charge of the nucleus, a relatively small integral multiple of the electronic charge; mass of the electron, (9.01×10^{-28} grams), together with Planck's constant (6.6×10^{-27} erg-seconds), are capable of being combined so as to determine a quantity of the dimensions of a length, is

A. that this is the basis of the determination, in Bohr's theory, of the wave lengths of lines in the spectrum characteristic of an element.
B. that this suggests the converse possibility of explaining Planck's constant, and so accounting for the quantization of radiation, as an effect due to the size of the atom.
C. that stable atoms must have a certain distance from one another to avoid mutual disturbances which might disrupt them.
D. that it indicates the possibility of giving a theoretical explanation for the minute size of the nucleus, and simultaneously accounting for the stability of the atom.
E. that it indicates that the introduction of Planck's constant into atomic theory, in connection with some condition governing the stability of the atom, might result in a theoretic determination of atomic size.

551. (4.20) Which of the following is a proposition set forth by Bohr which constitutes the concrete application of the idea suggested in the preceding question?

A. The frequencies of lines in the hydrogen spectrum are given by Rydberg's formula ($Rv/n_1^2 - Rc/n_2^2$), where the factor R is equal to $2\pi^2me^4/h^3c$.
B. Transitions within the atom cannot start from energy levels in which the distance of the electron from the nucleus is greater than the distances between atoms.
C. The radius r of a hydrogen atom is related to its ionization energy W by the equation $2r = e^2/W$.
D. Radiation is emitted from the atom in the form of homogeneous (monochromatic) quanta, the loss of an amount of energy $\triangle E$ being accompanied by radiation of frequency f, where $\triangle E = -hf$.
E. Only those circular orbits are possible in a hydrogen atom, for which the ionizing energy W is an integral multiple of $hw/2$; orbits satisfying this condition have radii equal to $n^2h^2/4\pi^2me^2$, where n may be any integer.

552. (4.20) Among the quantities mentioned in item 550 as characterizing the Rutherford atom, the mass of the nucleus was not included. This omission is due to the fact that

A. in the Rutherford model, the mass of the nucleus is practically identical with the mass of the atom.
B. Rutherford suggested that the mass of the nucleus is proportional to its charge; thus the charge of the nucleus is sufficient to determine its mass.
C. the mass of the nucleus is regarded, in Bohr's first approximation, as practically infinite compared to that of the electron, and so its value plays no role in determining properties of the atom.
D. the mass of the nucleus is not regarded as an "independent" property of the Rutherford atom, but is required to be determined theoretically as a consequence of intra-atomic forces.
E. the mass of the nucleus is not a fixed characteristic of the Rutherford model, since it varies from element to element.

Items 553 - 555 are essay questions. Before writing, plan your thoughts carefully and pay particular attention to the effectiveness of your presentation. The quality of your answer is of more value than its length.

In 1811 a young Italian physicist named Amadeo Avogadro made a proposal which played an important part in subsequent understanding of the structure of matter. One hundred and two years later a young Danish physicist, Neils Bohr, working in England, also made a proposal which played an important part in subsequent understanding of the structure of matter.

553. (5.10) For each case state the proposal and the problem it attempted to solve.

554. (5.10) What earlier observations and theories were drawn upon in formulating each proposal?

555. (5.10) Compare the scientific "climates of opinion" in the two instances. Consider the ease of verification in each case, the reception given to each and the attitudes of contemporary scientists.

556. (6.20) The attraction of the nucleus for electrons diminishes as the intervening space increases. Which of the following is the best experimental evidence for this statement?

- **A.** Alkali metals have many properties in common.
- **B.** Gas spectra consist of a series of sharp lines.
- **C.** Beta-ray emission does not change the atomic weight of the radioactive element.
- **D.** Iodine is chemically less active than is chlorine.
- **E.** None of the above is good evidence.

557. (6.20) Ag$^+$ ions have a greater tendency to unite with electrons than do Al^{+++} ions. Which of the following is the best experimental evidence for this statement?

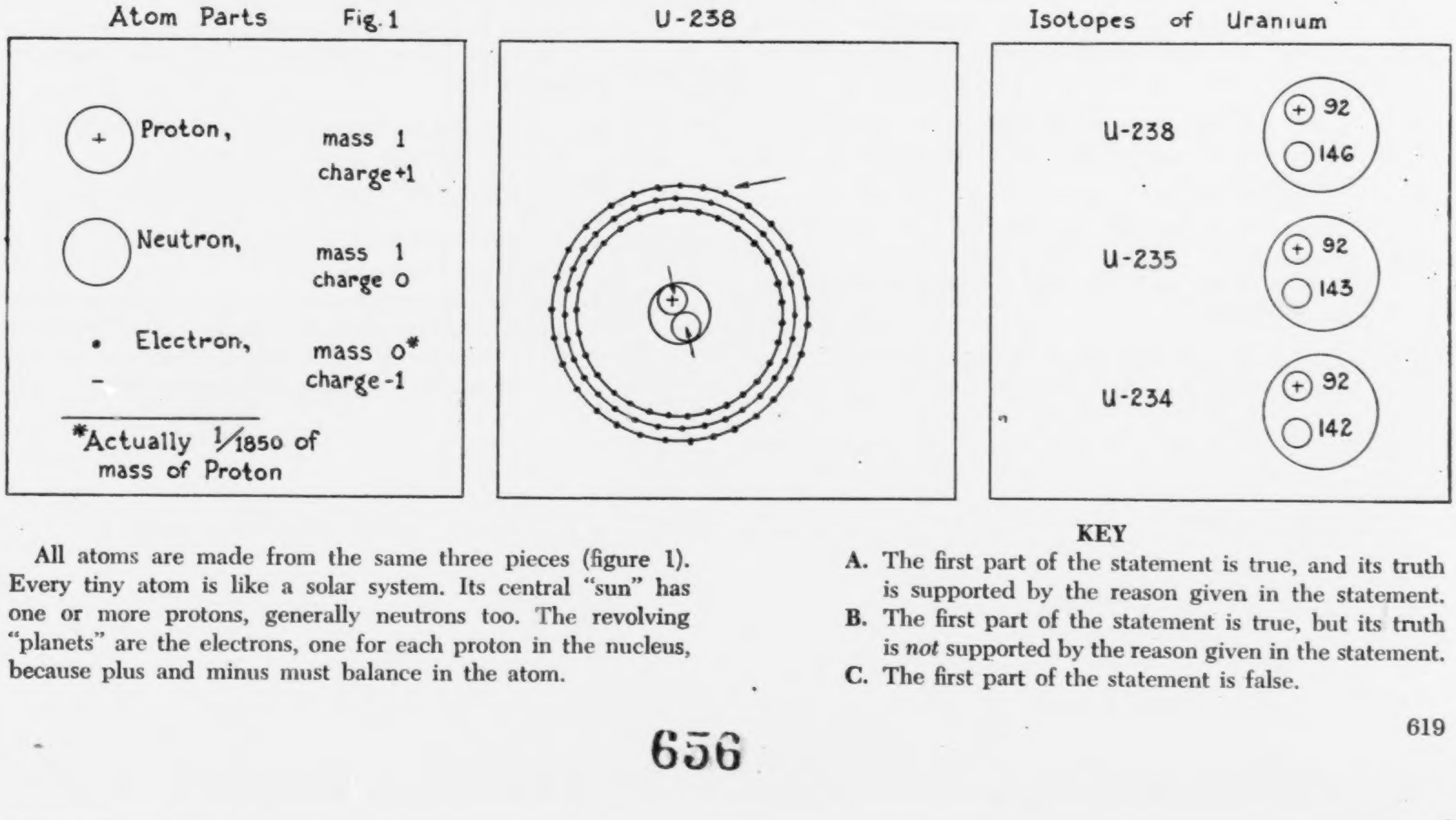
- **A.** Silver has a higher atomic weight than does aluminum.
- **B.** A strip of aluminum becomes covered with silver when dipped into a silver nitrate solution.
- **C.** Silver has a valence of 1+; aluminum has a valence of 3+.
- **D.** Silver is a better conductor of electricity than is aluminum.
- **E.** Silver chloride is insoluble; aluminum chloride is soluble.

558. (6.20) Dalton's Atomic Theory is

- **A.** a good example of absolute truth.
- **B.** a good example of the static view of science.
- **C.** correct, and led to more scientific discoveries.
- **D.** partially in error, but led to more scientific discoveries.
- **E.** neither correct nor in error. Nothing more was done about it.

For items 559 - 569 refer to this article "How Atom Splitting Releases Energy" in *The Atom—New Source of Energy*. By permission. McGraw-Hill Publishing Co., Pp. 2 - 3.

Diagram K



All atoms are made from the same three pieces (figure 1). Every tiny atom is like a solar system. Its central "sun" has one or more protons, generally neutrons too. The revolving "planets" are the electrons, one for each proton in the nucleus, because plus and minus must balance in the atom.

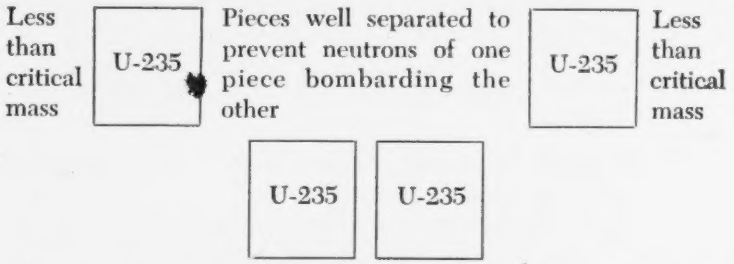
The opposite charges attract but high speed keeps the electrons in their circular paths. All the weight of the atom may be considered to be in the nucleus since the electron weighs only 1/1850 of the proton.

The atom is mostly empty space. If the nucleus were enlarged to the size of a baseball, the electron would be a mere speck 2000 feet away. Electrons supply the energy for chemical reactions like burning coal or the explosion of TNT. The nucleus evades all ordinary chemical reactions. Its energy can be released only by direct hits on the nucleus to break the bonds that hold the protons and neutrons in a tight bundle.

Uranium is Nature's heaviest atom called U-238. It is not directly usable for energy release, but an element may have several isotopes—alternate forms with the same number of protons but slightly different numbers of neutrons. The material needed for direct atomic energy release is U-235 which consists of only .7 per cent of natural uranium. The separation of the uranium isotopes is difficult since they are chemically the same element.

Relatively slow neutron bullets can split U-235 into lighter atoms and give several neutrons to split other U-235 atoms setting up a chain of explosions that may sweep through a block of U-235 releasing energy equivalent to 11,400,000 kilowat-hours per pound.

We now have a man-made new element, number 94 with 145 neutrons, called plutonium which can also be split like U-235. In an elementary way, the principle of atomic explosion can be shown by a diagram:


Less than critical mass
U-235
Pieces well separated to prevent neutrons of one piece bombarding the other
U-235
Less than critical mass
U-235
U-235

Bringing pieces together rapidly creates more than the critical mass thus starting an explosive chain reaction.

For items 559 - 569, concerned with the article on atomic energy, select from the key the most appropriate response.

KEY

- **A.** The first part of the statement is true, and its truth is supported by the reason given in the statement.
- **B.** The first part of the statement is true, but its truth is *not* supported by the reason given in the statement.
- **C.** The first part of the statement is false.

559. (6.20) The chance of a direct hit on the nucleus by an electron bullet is good because the atom is mostly empty space.

560. (6.20) Plutonium is element 94 because it has 94 electrons.

561. (6.20) Centripetal force keeps electrons in their orbit because electrons have no weight.

562. (6.20) U-235 and U-238 are not chemically the same because they have a different number of neutrons in their nuclei.

563. (6.20) The atoms of all elements are neutral because the neutron has no electric charge.

564. (6.20) The separation of U-235 and U-238 is most likely done by physical means because they are not chemically the same element.

565. (6.20) Ordinary chemical reactions do not affect the nucleus because the protons and neutrons are tightly held together.

566. (6.20) Electrons have no attraction electrically for the nucleus because the atoms are neutral in charge.

567. (6.20) Plutonium is heavier than U-238 as evidenced by its greater atomic weight.

568. (6.20) Radium should be suitable for atomic energy release because it gives off neutrons.

569. (6.20) A chain of explosive reactions may be started when more than a certain critical mass of U-235 is brought together because once the nucleus is hit, more neutrons are given off.

Items 570 - 577. After each item number on the answer sheet, blacken space

- **A.** if the statement is true and its truth is supported by the reason given.
- **B.** if the statement is true but its truth is not supported by the reason given.
- **C.** if the statement is false.

570. (6.20) Potassium reacts more vigorously than sodium, because its valence electron is closer to the nucleus of the atom.

571. (6.20) Chlorine reacts more vigorously than iodine, because its atomic radius is smaller than that of iodine.

572. (6.20) Non-metals lose electrons more readily than metals, because they have more electrons in their outermost shells.

573. (6.20) Acetic acid is a weaker acid than hydrochloric acid, because each molecule of acetic acid can release only one hydrogen ion.

574. (6.20) When zinc reacts with hydrochloric acid, zinc atoms become zinc ions. The hydrogen ions of the acid act as the oxidizing agent, because they gain electrons from the zinc atoms.

575. (6.20) When hydrogen ions acquire electrons, the change is reduction, because electrons have been gained.

576. (6.20) Only an electric current can be used to reduce aluminum to the metallic state, because no other reducing agent is sufficiently vigorous.

577. (6.20) The gases of Group O of the periodic table do not react chemically with other elements, because they do not gain or lose electrons under chemical conditions.

Items 578 - 583 are to be answered in accordance with the following key:

KEY

- **A.** The statement has been proved by experiment or observation.
- **B.** The statement is theoretical or hypothetical.
- **C.** The statement is a definition.
- **D.** The statement has been proved false by experiment or observation.

578. (6.20) The mass of 1 cc. of water at 4°C. is one gram.

579. (6.20) The gravitational attraction is the same at all places on the surface of the earth.

580. (6.20) The number of different kinds of atoms is limited.

581. (6.20) The acceleration of a body is equal to the time rate of change of velocity.

582. (6.20) The mass of a hydrogen atom is 100 times that of an electron.

583. (6.20) The number of molecules in a liter of a gas at 0°C. and 76 cm. of mercury pressure is the same as the number of molecules in a liter of any other gas at the same pressure and temperature.

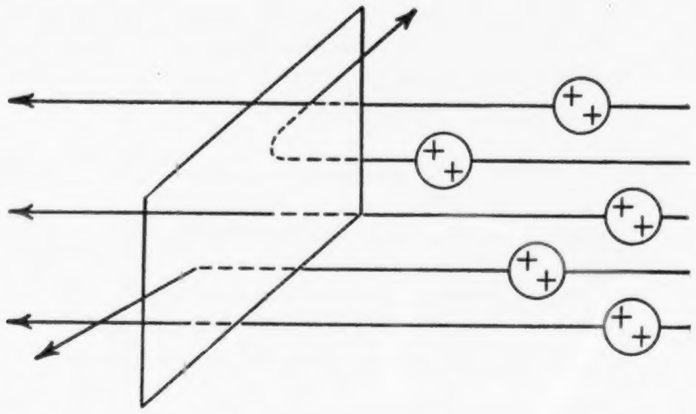
584. (6.20) A physicist, using the accumulated data concerning the nature of the atomic nucleus, constructed a model of the nucleus of a certain atom. In doing this, he used the physical laws known to describe the behavior of large-scale phenomena. He discovered, however, that the theoretical behavior of his model did not agree with the actual behavior of the atomic nucleus. After checking carefully his original data, checking carefully his mathematics, and trying models of the muclei of the atoms of several different elements, the results still did not agree. If all of the statements in the above paragraph are accepted as true, the most acceptable conclusion would be that

- **A.** the physical laws describing the behavior of large-scale phenomena were incorrect.
- **B.** the atomic nucleus behaved independently of natural laws.
- **C.** he must have made a mistake in the way that he constructed his model.
- **D.** the accepted system of mathematics was incorrect.
- **E.** the physical laws operating in the case of the large-scale phenomena and small-scale phenomena may not be entirely consistent with one another.

17. *X-Rays, Radioactivity, and Radiation—Nuclear Reaction*

X-RAYS, RADIOACTIVITY, AND RADIATION— NUCLEAR REACTION

Items 1 - 4. After each exercise number on the answer sheet, blacken the *one* lettered space which designates the correct answer.



1. This is an historically famous experiment performed by
(1.10)

A. Moseley. **B.** Thomson. **C.** Rutherford.
D. Millikan. **E.** Urey.

2. Gold was used because it
(1.10)

A. can be obtained as a nugget.
B. is a lightweight atom.
C. is malleable and can be prepared easily into a very thin sheet.
D. is yellow.
E. was believed to be different from other atoms.

3. Particles used as projectiles in this experiment were
(1.10)

A. electrons. **B.** alpha particles.
C. beta particles. **D.** gamma rays. **E.** neutrons.

4. The experiment gives excellent evidence that nuclei are
(2.20)

A. very close together and positively charged.
B. very close together and neutral in character.
C. very far apart and neutral in character.
D. very far apart and charged positively.
E. very far apart and charged negatively.

5. Cosmic rays are usually considered to be
(1.10)

A. by-products of some process of atomic creation.
B. by-products of atomic annihilation.
C. diffused radiation in space congealing into particles of matter—electrons, atoms, and molecules.
D. high-energy radiation coming from the far reaches of interstellar space.

6. Atomic energy changes are spontaneous in all of these
(1.10) *except*

A. platinum. **B.** uranium. **C.** radium.
D. thorium. **E.** plutonium.

7. Which of the following is not true of cathode rays?
(1.10)

A. They change in character as the gas in the tube is changed.
B. They travel in straight lines unless deflected by a magnetic or an electric field.
C. They can be brought to a focus.
D. They cause some materials to fluoresce.
E. They cast shadows of obstacles placed in their path.

8. A characteristic of infra-red radiations is
(1.10)

A. the ability to fade dyes and kill bacteria.
B. their heating power.
C. the ability to cause tanning.
D. their inability to pass through ordinary window glass.
E. their pale blue color.

Items 9 - 15. The following excerpt reprinted, by permission, from TIME Magazine, July 21, 1947. Copyright Time, Inc., 1947. Read the excerpt and answer the items based on the italicized words of the passage.

Smithereens

As atom smashing goes, the ***uranium*** (9) bomb is a comparatively gentle affair. Fissioning the uranium atom is roughly comparable to cracking a ripe coconut in half with a well placed tap: the atom splits neatly into two pieces (lighter atoms) and two or three almost infinitesmal particles *(neutrons)* (10) (11) that fly off like sparks. Atom smashers believe that they will eventually do much better than that.

. . . Last week some determined U.S. atom smashers, the cyclotron group at the University of California, cooly reported that the smithereenizing of the atom is now well on its way. They announced that they had smashed some atoms into 22 to 30 pieces.

This feat was accomplished by Cal's fantastic new 184-inch cyclotron, which packs the most powerful wallop ever achieved by man. Firing relatively heavy atomic bullets—*deuterons* (heavy hydrogen nuclei) (12) and *alpha particles* (helium nuclei) (13)—with a force of 200 million to 400 million electron volts, the cyclotron has almost ten times the power of the most potent cyclotron previously known (also at Cal.).

. . . Previous cyclotrons, they explained, had just chipped away at the atoms, knocking off two or three small particles. But the 184-incher's bullets cause such havoc in atoms that researchers have so far been unable to sort out all of the debris.

Sample smash: an arsenic atom (*atomic weight:* 75) (14) had 21 particles knocked off by a single blow, and was reduced to radioactive cobalt (atomic weight: 54). When the new cyclotron bombarded an oxygen atom (atomic weight: 16) with neutrons, the light atom split into five pieces.

Upshot: California's atom smashers have thus far produced some 100 new *isotopes* (15) of atoms to add to 450 previously known.

9. Uranium is
(1.10)

A. a radioactive compound.
B. a homogeneous mixture. **C.** a heavy element.
D. an unstable mixture.
E. the latest element to be discovered.

10. Neutrons of an element are
(1.10)

A. the same weight as protons of that same element.
B. negatively charged particles.
C. the same weight as an electron.
D. positively charged particles.

11. The loss of a neutron from an atom
(1.10)

A. changes the chemical nature of the atom.
B. changes the charge on the atom.
C. changes the physical properties of the atom (viz. the weight).
D. reduces the atomic number of the atom.
E. causes the subsequent loss of an electron.

12. A deuteron is
(1.10)

A. the nucleus of heavy hydrogen. **B.** a neutron.
C. an electron with a positive charge.
D. an atom of a recently discovered element.
E. a type of large molecule.

13. An alpha particle is
(1.10)

A. a helium nucleus. **B.** an electron.
C. a radioactive element. **D.** a negative particle.
E. a hydrogen atom.

14. The atomic weight of most atoms depends *almost* entirely upon the weight of the
(1.10)

A. electrons of the atom. **B.** protons of the atom.
C. electrons and protons of the atom.
D. protons and neutrons of the atom.
E. electrons and neutrons of the atom.

15. An isotope is
(1.10)

A. a new but unstable element. **B.** a new compound.
C. a form of an element which has different chemical properties but the same weight as another form of that element.
D. an old previously-known compound with the same chemical characteristics but a new molecular weight.
E. an atom of an element which has the same chemical characteristics as another atom of the element but different atomic weight.

16. The element plutonium gained special significance recently in connection with the development of
(1.10)

A. qualitative analysis of the composition of the planets.
B. heat resistant steels for power jets.
C. the release of atomic energy.
D. the complete periodic table.
E. research in some area other than one of the above.

17. Separation of the isotopes of uranium requires a physical method rather than a chemical method because
(1.10)

A. it is too dangerous to mix other chemicals with uranium.
B. they are chemically the same element.
C. they differ in number of neutrons.
D. it is the heaviest element in nature.
E. natural uranium contains only 0.7% U-235.

18. When a beam of X-rays, all of the same wave length, is directed against a very fine wire the shadow formed or photographed in back of it is not just that of a single wire but rather as if several wires were used. The best explanation of this involves
(1.10)

A. diffraction. **B.** reflection.
C. the Doppler effect. **D.** an optical illusion.
E. refraction.

19. Atomic energy changes are spontaneous in all of these *except*
(1.10)

A. platinum. **B.** uranium. **C.** radium.
D. thorium. **E.** plutonium.

20. The changing of the amplitude of the carrier wave of a broadcast station to transmit a program is called
(1.10)

A. detection. **B.** oscillation. **C.** rectification.
D. amplification. **E.** modulation.

21. The term radioactivity refers to
(1.10)

A. the activity of electronic devices.
B. the spontaneous disintegration of certain atomic nuclei.
C. the gain or loss of electrons from the outer orbits of the atoms.
D. certain elements, like cobalt, which are necessary in television and radio manufacture.
E. the chemical combinations between elements catalyzed by radio frequency waves.

22. The half-life of a radioactive substance is
(1.10)

A. half the life-span of the substance.
B. usually 50 years.
C. the time for radium to change to lead.
D. found from Einstein's equation, $E = mv^2$.
E. the time for half the material to disintegrate.

For items 23 - 28, mark the appropriate answer space

A. if the item is true of $^{235}_{92}$U.
B. if the item is true of $^{238}_{92}$U.
C. if the item is true of $^{239}_{92}$U.
D. if the item is true of $^{239}_{94}$Pu.
E. if the item is true of none of the above.

23. The isotope of uranium of greatest abundance in ordinary uranium.
(1.10)

24. Is produced when one neutron, $^1_0$N enters the nucleus of an atom of U-238.
(1.10)

25. Is produced from U-239 through the loss of first one electron and then another.
(1.10)

26. Is the original source of the neutrons in the uranium pile used in the production of plutonium.
(1.10)

27. Is the chief source of the energy of the sun.
(1.10)

28. Along with plutonium, it may be used to produce an atom bomb.
(1.10)

Items 29 - 31. True or False. Consider each lettered statement independently and mark it T or F as appropriate.

29. **A.** Alpha rays belong to the electromagnetic spectrum.
(1.10) **B.** Radium is the only heavy element that is naturally radioactive.
C. All radioactive elements emit alpha, beta, and gamma rays.
D. Some man-made isotopes are radioactive.
E. The mass number of an element minus its atomic number gives the number of neutrons in the nucleus of the element.

30. **A.** Robert Millikan discovered the electron.
(1.10) **B.** J. J. Thomson was a great American scientist.
C. Lisa Meitner invented the atom bomb.
D. Enrico Fermi has contributed greatly to our knowledge of nuclear physics.
E. The atomic bomb exploded over Los Alamos was shot from a cyclotron.

31. (1.10)
A. Rich deposits of uranium ore are found in this country.
B. Radium occurs with uranium ore.
C. Uranium-238 occurs as one pound for every 140 pounds of pure uranium.
D. Plutonium is an isotope of uranium.
E. There are chemical methods for separating the isotopes of an element.

32. (1.10) Radiant energy consists of

A. photons. **B.** protons. **C.** neutrons.
D. positions. **E.** electrons.

33. (1.10) The frequencies of the spectral lines in the Balmer series of hydrogen can be written $f + R\left(\frac{1}{2^2} - \frac{1}{n^2}\right)$. The line of lowest frequency occurs when n is

A. 1. **B.** 2. **C.** 3. **D.** 4. **E.** 5.

34. (1.10) In considering the various "rays" from radioactive material we think of beta rays as

A. high-frequency X-rays. **B.** high-speed electrons.
C. infra-red radiation. **D.** hydrogen nuclei.
E. helium nuclei.

35. (1.10) An alpha particle from radioactive material is

A. a helium atom from which two electrons have been removed.
B. an aggregate of two or more electrons.
C. a hydrogen atom.
D. the ultimate unit of positive electricity.
E. sometimes negatively charged.

36. (1.10) When electromagnetic radiations from inside and from outside the nucleus are compared, those from within the nucleus have

A. shorter wavelengths. **B.** lower frequencies.
C. less energy. **D.** lower speeds.
E. smaller equivalent mass.

37. (1.10) X-rays emerge from a metal target when it is struck by

A. radiation of long wave length.
B. high-velocity alpha particles.
C. high-velocity neutrons.
D. high-velocity electrons. **E.** cosmic rays.

38. (1.10) By the term "cathode rays" we refer to

A. a stream of positive ions.
B. electromagnetic waves of very short wave length.
C. a beam of X-rays. **D.** a stream of electrons.

39. (1.10) Of the so-called "rays" emitted by radioactive substances, the beta rays are considered to be

A. high-frequency X-rays. **B.** high-speed electrons.
C. high-energy electromagnetic radiation.
D. a stream of photons. **E.** fast helium nuclei.

40. (1.10) The mass of an electron is

A. the same as the mass of the hydrogen atom.
B. dependent upon the atomic weight of the atom from which it was separated.
C. the same as the mass of a proton.
D. about one two-thousandth the mass of a hydrogen atom.
E. about four times the mass of a hydrogen atom.

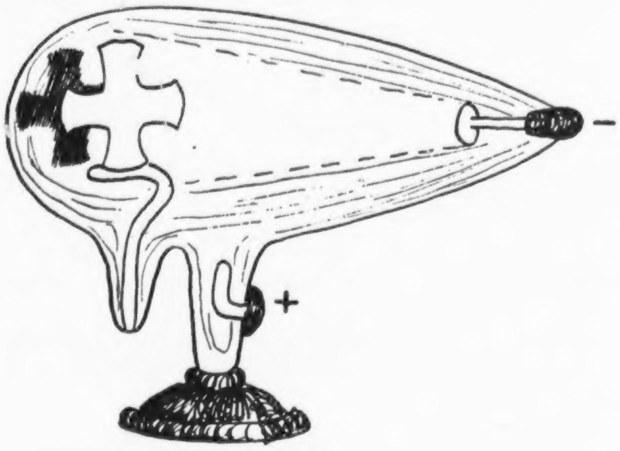
41. (1.10) Cathode rays are

A. the most effective projectiles in the disintegration of atoms.
B. particles which go from cathode to anode in the electrolysis of aqueous solutions.
C. very light negatively charged particles which travel from cathode to anode in a Crookes tube.
D. similar to the alpha particles of radium except for their speed.
E. differ from X-rays only in their wave-length.

42. (1.10) X-rays are

A. electromagnetic waves of short wave-length.
B. negatively charged ions.
C. reflected cathode rays.
D. nuclei of hydrogen atoms. **E.** positrons.

Items 43 - 47 refer to the following diagram. The diagram represents one kind of a cathode-ray tube. After each exercise number on the answer sheet, blacken the *one* lettered space which designates the correct answer.



43. (1.10) Cathode rays are composed of

A. positive ions. **B.** negative ions. **C.** electrons.
D. both positive and negative ions.
E. none of the items mentioned in A, B, C, or D.

44. (1.10) In a cathode tube the mass of the electron

A. depends on the kind of anode metal.
B. depends on the kind of cathode metal.
C. is independent of the anode or cathode metal.
D. depends on the gas in the tube.
E. is independent of the factors mentioned in A, B, C, or D.

45. (1.10) When cathode rays strike a metal target the radiation emitted from the target is most similar to

A. a stream of electrons. **B.** gamma rays from radium.
C. a beam of alpha particles. **D.** fluorescent light.
E. a stream of protons.

46. (1.10) The tube *pictured* is most useful in showing that cathode rays

A. travel in a straight line.
B. possess kinetic energy.
C. cause X-rays to be emitted from glass.
D. travel with the speed approaching that of light.
E. are positively charged.

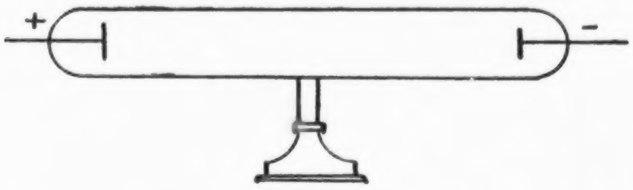
47. (1.10) The cathode in a different kind of cathode tube is in the center of the tube and consists of a metal disc containing several holes. Cathode rays travel toward the positive electrode at one end of the tube, while other rays or particles pass through the holes in the cathode in the opposite direction. These rays or particles are

A. X-rays. **B.** positive rays or protons.
C. beta particles. **D.** neutrons. **E.** positrons.

48. (1.10) All *except* one of the following are properties of X-rays. You are to select this one item which does *not* apply.

A. The ability to make certain materials fluoresce.
B. The ability to pass through opaque matter.
C. The tendency to ionize the air through which they pass.
D. The ability to cause a tiny paddle wheel to move away from the cathode.
E. The ability to darken a photographic plate.

Items 49 - 51 refer to the following diagram.



49. (1.10) In a tube similar to the one shown above, cathode rays were discovered by

A. Crookes. **B.** Moseley. **C.** Thomson.
D. Rutherford. **E.** Curie.

50. (1.10) Roentgen found that if a target were placed in the path of cathode rays, energy was released that came to be known as

A. beta rays. **B.** cosmic rays. **C.** neutrons.
D. X-rays. **E.** alpha rays.

51. (1.10) Very lightweight objects that are free to rotate are set into motion by cathode rays, thus proving the rays possess

A. negative charge. **B.** positive charge.
C. neutral charge.
D. both mass and motion or kinetic energy.
E. potential energy.

Items 52 - 61. After each item number on the answer sheet, blacken space

A. if the item is true of cathode rays only.
B. if the item is true of positive rays only.
C. if the item is true of both cathode and positive rays.
D. if the item is true of neither.

52. (1.10) Consist of the residue of molecules which have lost one or more electrons.

53. (1.10) Move toward the electrode which has the same charge as they themselves bear.

54. (1.10) Consist of a stream of electrons.

55. (1.10) Are identical, irrespective of metal in the anode or cathode or gas in the tube.

56. (1.10) Vary with gas or material in the tube.

57. (1.10) Are deflected by magnetic or electrical fields.

58. (1.10) Magnitude of their charge is either equal to or a multiple of the fundamental charge on the electron.

59. (1.10) May have a mass equal to that of the proton if the gas in the tube is hydrogen.

60. (1.10) Are uncharged particles.

61. (1.10) Mass is 1/1850 of that of the hydrogen atom.

For items 62 - 64 select the appropriate answer from the following key:

KEY

A. Alpha particles. **B.** Beta particles.
C. Cathode rays. **D.** Gamma rays.
E. Positive rays.

62. (1.10) Are not affected by the most intense magnetic fields. Are very penetrating and of very short wave length.

63. (1.10) Are slightly bent by intense magnetic fields. One of the products of the disintegration of radium. Each particle carries two positive charges.

64. (1.10) Are greatly deflected even by weak magnetic fields. Consist of electrons and are one of the products of the disintegration of radium.

65. (1.10) Cathode rays are

A. electromagnetic waves. **B.** photons.
C. neutrons. **D.** electrons. **E.** protons.

66. (1.10) The basic difference between an X-ray tube and a cathode-ray tube is that

A. the cathode ray tube contains a vacuum.
B. the X-ray tube has both a cathode and an anode.
C. the cathode-ray tube contains electrodes.
D. the X-ray tube stops the flow of electrons.
E. the X-ray tube produces a stream of electrons from the cathode.

67. (1.10) The term, "Atomic Energy," refers to energy obtained from

A. the electron clouds which surround atoms.
B. reactions between two different atoms.
C. endothermic chemical reactions.
D. within the nucleus of the atom.
E. electrons passing into different energy levels.

68. (1.22a) The maximum kinetic energy of photoelectrons from an illuminated surface increases

A. when the light intensity increases.
B. when the light intensity decreases.
C. when the light frequency increases.
D. when the light frequency decreases.
E. independently of light intensity and frequency.

69. (1.22a) When electrons are emitted from a clean zinc plate illuminated by ultra-violet light the kinetic energy of an emitted electron is

A. directly proportional to the intensity of the illumination.
B. dependent only on the frequency of the incident light.
C. independent of the frequency of the incident light.

70. (1.22a) If the following electromagnetic radiations are supposed to be arranged in order of increasing wave length, the one which is out of place is

A. gamma rays. **B.** ultra-violet. **C.** infra-red.
D. X-rays. **E.** radio waves.

For items 71 - 80 use the following key:

KEY

A. The statement is a fact.
B. The statement is an hypothesis.
C. The statement is a mere guess.

71. (1.23) ( ) If fission occurs in any heavy element, a chain reaction will result.

72. (1.23) ( ) The scientist knew that if Hahn had produced barium by neutron bombardment of uranium that he had split the atom.

73. (1.23) ( ) Slow neutrons will cause fission of U-235 but not of the other U-238.

74. (1.23) ( ) The capsule of beryllium at the center of a plutonium bomb (Greenglass version) furnishes additional neutrons to those caused by the fission of the plutonium.

75. (1.23) ( ) The "Tamper" (the force that holds the bomb together until a chain reaction is well under way) is an auxiliary explosion directed from all directions toward the center of the bomb.

76. (1.23) ( ) The atomic bomb has the shape of a cigar but it weighs thousands of pounds.

77. (1.23) ( ) The H bomb weighs less than the atomic bomb but it is thousands of times more powerful.

78. (1.23) ( ) From theoretical considerations the H bomb should be many times as powerful as an A bomb.

79. (1.23) ( ) Atomic energy research originated in the 19th century.

80. (1.23) ( ) When an atom bomb is exploded, new elements are formed plus some spare parts and a considerable amount of energy.

81. (1.25) The most acceptable method for estimating the age of the earth is related to the

A. rate of increase of salt in the ocean.
B. radioactive changes in the lithosphere.
C. rate of melting of present glaciers.
D. thickness of and rate of deposition of sedimentary layers.
E. rate of cooling of the centrosphere.

82. (1.25) X-rays result from the bombardment of a suitable target by high speed

A. electrons. **B.** ions. **C.** protons.
D. neutrons. **E.** atoms.

83 (1.25) Cosmic rays may be audibly detected by

A. a fluorescent tube. **B.** the cyclotron.
C. the oscilloscope. **D.** the Geiger counter.
E. the stroboscope.

84. (1.25) An individual who has pursued an extensive curriculum in those sciences dealing with a study of living things as well as the activity of radioactive particles within living things, would be considered a

A. biophysicist. **B.** biochemist. **C.** alchemist.
D. anatomist. **E.** geologist.

For items 85 - 89 select from the key the most appropriate apparatus.

KEY

A. Zinc-sulphide fluorescent screen.
B. Wilson cloud-chamber. **C.** Geiger counter.
D. Mass spectrograph.

85. (1.25) Used to photograph such phenomena as the track of an alpha particle.

86. (1.25) Used to determine the "weight" of an atom.

87. (1.25) Used to determine the rate of disintegration of radioactive substances and the velocity and energy of the emitted particles.

88. (1.25) Used to determine the rate of disintegration of atoms but not the velocity and energy of the emitted particles.

89. (1.25) Commonly used to detect cosmic rays audibly.

Items 90 - 95. After each item number on the answer sheet, blacken the *one* lettered space which designates the term below to which the item correctly refers.

KEY

A. Fog-track apparatus. **B.** Electroscope.
C. Geiger counter. **D.** Mass spectrograph.
E. None of the above.

Item 90 deleted.

91. (1.25) Used by Madame Curie to detect the presence of radioactive material.

92. (1.25) Artificial transmutation of elements was first detected by the use of this instrument.

93. (1.25) Can distinguish positive electric charges from negative ones, is commonly used for this purpose.

94. (1.25) Makes the paths of ionizing particles visible.

95. (1.25) Used in prospecting for uranium.

Items 96 - 106. The items to which you will respond have been selected from various sources. Mark in bracket

1. if you believe that a statement is a scientific fact.
2. if you believe a statement is an opinion.

Sample items:

Statement of Fact. 1. Growth is a characteristic of cancer tissue.
Statement of Opinion: 1. The cause of cancer will never be discovered.

1. 2.

96. (1.25) ( ) ( ) Uranium-235 has less mass than U-238.

97. (1.25) ( ) ( ) The search for uranium in the United States will result in an adequate supply of the ore.

98. (1.25) ( ) ( ) The atomic bomb does not make all methods of warfare obsolete.

99. (1.25) ( ) ( ) An atomic bomb raid is no more damaging that a saturation bombing with fire bombs or block busters.

100. (1.25) ( ) ( ) The hydrogen bomb is the most potent weapon of war that science will ever produce.

101. (1.25) ( ) ( ) Sonar and radar diminish the effectiveness of large navies.

102. (1.25) ( ) ( ) The United States should never again use the A-bomb unless it is first used on us.

103. (1.25) ( ) ( ) Decentralization is a defense against the atom bomb.

104. (1.25) ( ) ( ) There are safety measures to be taken against the atomic bomb.

105. (1.25) ( ) ( ) Uranium is a source of power.

106. (1.25) ( ) ( ) Radioactivity is the least of the atomic bomb's threats.

107. (1.25) In positive-ray analysis

A. a combination of magnetic and electrical fields sorts out atoms according to their atomic number.
B. cathode rays are separated into groups according to their ratio of mass to charge.
C. positively charged atoms are split into groups according to their group number in the periodic table.
D. atoms of the same mass and charge hit a photographic plate at the same point.
E. isotopes of the same element converge to the same point on a photographic plate.

108. (1.30) Which of the following does not appear on the electromagnetic spectrum?

A. Cosmic rays.
B. Hertzian waves.
C. X-rays.
D. Seismic waves.
E. Ultra-violet rays.

109. (1.30) Radioactive disintegration may be characterized by all of these except

A. the emission of alpha, beta, and gamma rays.
B. definite half-life periods.
C. the formation of helium as a by-product.
D. the ejection of large quantities of matter.
E. transmutations of elements.

110. (1.30) A radioactive element X emits beta particles (electrons). This results in the production of

A. an element which is very reactive chemically.
B. an element of higher atomic number.
C. an element with an atomic weight one unit less.
D. a radioactive element which emits protons.
E. stable positive ions of the element X.

111. (1.30) In the photo-electric effect, the maximum speed of an electron ejected by a photon is determined

A. entirely by the frequency of the light falling on the metal surface.
B. entirely by the number of photons falling on the metal surface.
C. entirely by the nature of the metal surface.
D. by the frequency of the light and the number of photons falling on the metal surface.
E. by the nature of the metal surface and the frequency of light falling on the surface.

112. (1.30) The energy released when uranium (238) atoms disintegrate results from

A. the change of uranium into radium.
B. the emission of high speed electrons.
C. the conversion of matter to energy.
D. the formation of the isotope U^{235}.
E. the emission of alpha particles.

113. (1.30) The principle underlying the operation of a photoelectric cell is:

A. Radiation may cause some substances to emit electrons.
B. Electrons may be emitted from certain substances at high temperatures.
C. A changing magnetic or electro-magnetic field may produce a flow of electrons.
D. Radiation may be re-radiated at different wave lengths.
E. Electrons may cause radiations to be emitted from some substances.

114. (1.30) When atoms are emitting or absorbing energy

A. protons change place with electrons.
B. neutrons are escaping or being captured.
C. electrons change their energy levels.
D. the evidence is always visible to the eye.
E. the atomic number of the atom is raised or lowered.

115. (1.30) Energy resulting from motion of particles deep within the structure of the atom was unknown until the discovery of

A. ionization.
B. the atomic bomb.
C. the photoelectric effect.
D. electromagnetic radiation.
E. radioactivity.

116. (1.30) The photoelectric effect involves the

A. emission of electrons from an illuminated metallic surface.
B. emission of light when radioactive material strikes a zinc sulfide screen.
C. process of developing photographs using the electric current.
D. emission of visible light by high voltage electricity.

117. (1.30) The Edison effect refers to the

A. emission of electrons from an illuminated metallic surface.
B. emission of sound waves from phonograph needles.
C. conversion of electric current into visible light.
D. emission of electrons from hot metals.

118. (1.30) The energy produced in a nuclear fission bomb is the result of the

A. disappearance of an equivalent amount of mass.
B. energy produced by a chemical reaction.
C. energy of combustion of the subdivided atoms.
D. energy of the neutrons which are sent in all directions.
E. energy of the gamma rays.

Items 119 - 126. For each of the following nuclear changes, blacken space

- **A.** if the item is true of the loss of a neutron.
- **B.** if the item is true of the loss of an alpha particle.
- **C.** if the item is true of the loss of a beta particle.
- **D.** if the item is true of the capture of a neutron.
- **E.** if the item is true of none of the above nuclear transformations.

119. (1.30) The atomic weight decreases by four and the atomic number decreases by two.

120. (1.30) An element of group III moves two places to the left in the periodic chart.

121. (1.30) An element of group II moves one place to the right in the periodic chart.

122. (1.30) The atomic weight decreases by one but the atomic number remains the same.

123. (1.30) There is no change in either the atomic weight or the atomic number.

124. (1.30) The atomic weight increases by one but the element remains in the same place in the periodic chart.

125. (1.30) The atomic weight remains the same but the atomic number increases by one.

126. (1.30) The ejected particle will eventually pick up two planetary electrons and become a neutral helium atom.

127. (1.30) The difference between chemical reactions and nuclear reactions is that chemical reactions involve

- **A.** chemicals and nuclear reactions do not.
- **B.** the formation of new substances and nuclear reactions do not.
- **C.** the formation of new elements and nuclear reactions deal with the formation of radioactive elements.
- **D.** outer electron changes usually and nuclear reactions involve changes within the nuclei of the atoms.
- **E.** elements or compounds only while nuclear reactions are those taking place between nuclei of atoms.

Items 128 - 136. After each item number on the answer sheet, blacken space

- **A.** if the item is true of the photoelectric effect.
- **B.** if the item is true of the Edison effect.
- **C.** if the item is true of both effects.
- **D.** if the item is true of neither effect.

128. (1.30) Electrons are emitted from a heated filament.

129. (1.30) Electrons are emitted from a metal or compound when exposed to light.

130. (1.30) The conductor which is to receive the electrons must be connected to the positive terminal of the battery or direct current source.

131. (1.30) The metal which emits the electrons must be connected to the positive terminal of the direct current source.

132. (1.30) The flow of electrons is unidirectional.

133. (1.30) Forms the basis of the radio tube.

134. (1.30) The effect is often used to operate a relay which in turn may operate the electric switch on various devices.

135. (1.30) A grid may be employed to regulate the flow of electrons.

136. (1.30) The effect is utilized in tubes which change alternating into direct current.

137. (1.30) In the uranium disintegration series

- **A.** the disintegrating element merely throws off planetary electrons.
- **B.** when an element loses a beta particle, the production of another element takes place, that second element having an atomic weight one unit larger and an atomic number one unit smaller than the original atom.
- **C.** when an element loses an alpha particle an element is produced that has an atomic weight four units less and an atomic number two units less than those constants for the disintegrating atom.
- **D.** in all atomic disintegrations the nucleus is unaffected.
- **E.** the series of disintegrations continues until an element having eight electrons in its outermost orbital level is obtained.

138. (1.30) When uranium undergoes fission as a result of neutron bombardment, the energy released in the fission process is due to

- **A.** oxidation of uranium.
- **B.** the kinetic energy of the bombarding neutrons.
- **C.** the radioactivity of the uranium nucleus.
- **D.** the radioactivity of the fission products.
- **E.** the conversion of matter into energy.

139. (1.30) The curvature of the path (i.e., amount of deflection) of beta rays emitted by radioactive substances in an electric field, compared with the curvature of the path of cathode rays in the same field, is

A. less. **B.** the same. **C.** greater.
- **D.** either greater, less, or the same, depending on the relative speeds of cathode rays and beta rays.
- **E.** no comparison can be made, because beta rays are not affected by an electric field.

140. (1.30) At the present time which of the following items is *not* universally feasible?

- **A.** Use of radioactive isotopes in medicine.
- **B.** Atomic energy for power.
- **C.** Atomic energy for explosives.
- **D.** Radioactive isotopes in automotive studies.
- **E.** Atomic energy for production of isotopes.

141. (1.30) Substances are radioactive when

- **A.** the atomic nucleus is unstable.
- **B.** the orbital electrons are easily lost.
- **C.** the atom gains electrons readily.
- **D.** they readily form ions.
- **E.** they are chemically reactive.

142. (2.10) If thallium, element number 81, ejects a beta particle from the nucleus

- **A.** no new element is formed.
- **B.** mercury, element number 80, is formed.
- **C.** lead, element number 82, is formed.
- **D.** thallium becomes radioactive.

143. If radium, element number 88 in the periodic table,
(2.10) ejects an alpha particle from the nucleus

A. no change takes place, as radium is constantly ejecting alpha particles.
B. radon, element number 86, would be formed.
C. actinium, element number 89, would be formed.
D. thorium, element number 90, would be formed.
E. stable negative ions of radium would result.

Items 144 - 149. After each exercise number on the answer sheet, blacken the *one* lettered space which designates the correct answer.

"The first clue as to the nature of the unusual radioactive changes that were observed with uranium lay in the statement of Hahn and Strassman in January, 1939, that barium was found in the disintegration products." (The uranium referred to is one of the uranium isotopes and the atomic number of barium is 56.)

144. The above statement from your text book refers to
(2.10)

A. a chemical reaction of uranium and barium.
B. combustion of uranium and oxygen, barium is in the ashes.
C. U^{238} when blasted with X-rays, it fissions or disintegrates.
D. U^{235} when, in presence of neutrons, it undergoes fission.
E. U^{238} when, in presence of protons, it reacts to produce barium.

145. A radioactive isotope is an element which
(1.10)

A. has a high temperature.
B. is chemically reactive–orbital electrons are in an unstable state.
C. has a nucleus which undergoes a change with absorption of energy.
D. is chemically inert.
E. has a nucleus which spontaneously undergoes change liberating energy and often some kind of charged particle.

146. An explosion does not result from a small piece of U^{235}
(1.30) because

A. U^{235} does not fission.
B. the neutrons released move too fast to start a chain reaction.
C. U^{238} is needed.
D. so many neutrons escape a small piece of the metal that a chain reaction cannot start.
E. a little U^{236} is needed as a trigger.

147. Radioactive carbon ${}^{14}_{6}C$ has a half life of 4700 years. It
(2.10) changes slowly to ordinary nitrogen ${}^{14}_{7}N$ according to:

$${}^{14}_{6}C \rightarrow {}^{14}_{7}N + X$$

The particle X must be

A. a proton. **B.** a deuteron. **C.** an electron.
D. an alpha particle. **E.** a gamma ray

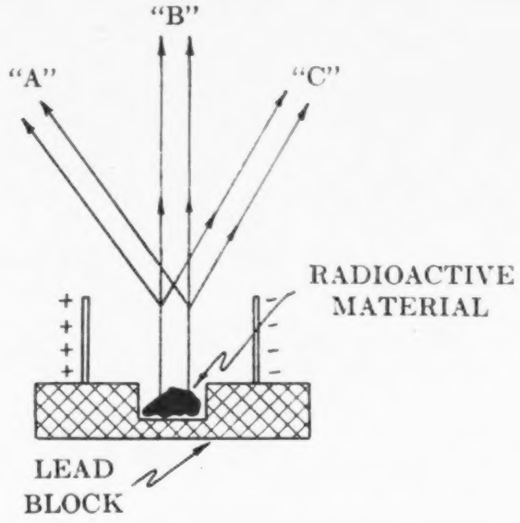
148. The atomic pile consists of bars of uranium interspersed
(1.25) with graphite rods. The purpose of the latter is to

A. furnish neutrons for the fission process.
B. react with U^{235} and release energy.
C. act as a neutron moderator slowing down fast neutrons.
D. release energy by combustion and this energy in turn triggers the atomic fire.
E. furnish deuterons to fission atoms of U^{238}.

149. The energy produced in a nuclear fission bomb is the
(1.30) result of the

A. disappearance of an equivalent amount of mass.
B. energy produced by a chemical reaction.
C. energy of combustion of the subdivided atoms.
D. energy of the neutrons which are sent in all directions.
E. energy of the gamma rays.

The following diagram and key apply to items 150-154 inclusive.



KEY

A. Gamma rays. **B.** Alpha rays. **C.** Beta rays.
D. Alpha and gamma rays. **E.** Beta and gamma rays.

The above diagram shows what happens to the radiation which is given off by radioactive material, when it comes under the effect of an electric field. From this information you are to select the *one* item in the key which best fits the situation described in the items below.

150. Those rays, "A," which are deflected as if they carried
(2.10) a negative charge are known as________.

151. Those rays, "B," which pass undeflected through an
(2.10) electric field are known as________.

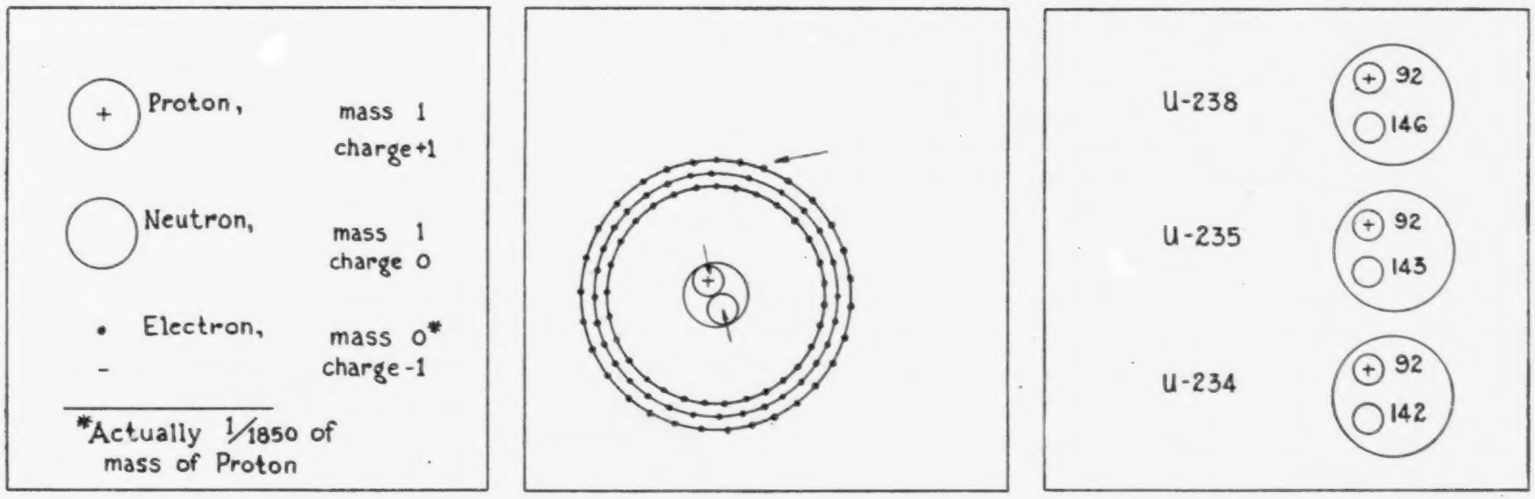
152. Those rays, "C," which are deflected as if they carried
(2.10) a positive charge are known as________.

153. Those rays which, by their reaction to the electron field,
(2.10) strongly suggest that they are electrons, are________.

154. Those rays which, by their reactions to the electric field,
(2.10) strongly suggest that they are not electrons, are________.

For items 155 - 164 refer to this article "How Atom Splitting Releases Energy" in *The Atom–New Source of Energy* printed by permission of the McGraw-Hill Publishing Co., pp 2-3. Refer to Diagram K.

Diagram K



All atoms are made from the same three pieces (figure 1). Every tiny atom is like a solar system. Its central "sun" has one or more protons, generally neutrons, too. The revolving "planets" are the electrons, one for each proton in the nucleus, because plus and minus must balance in the atom.

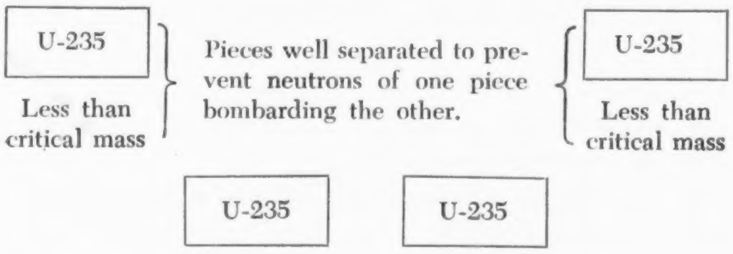
The opposite charges attract but high speed keeps the electrons in their circular paths. All the weight of the atom may be considered to be in the nucleus since the electron weighs only 1/1850 of the proton.

The atom is mostly empty space. If the nucleus were enlarged to the size of a baseball, the electron would be a mere speck 2000 feet away. Electrons supply the energy for chemical reactions like burning coal or the explosion of TNT. The nucleus evades all ordinary chemical reactions. Its energy can be released only by direct hits on the nucleus to break the bonds that hold the protons and neutrons in a tight bundle.

Uranium is Nature's heaviest atom called U-238. It is not directly usable for energy release, but an element may have several isotopes—alternate forms with the same number of protons but slightly different numbers of neutrons. The material needed for direct atomic energy release is U-235 which consists of only .7 per cent of natural uranium. The separation of the uranium isotopes is difficult since they are chemically the same element.

Relatively slow neutron bullets can split U-235 into lighter atoms and give several neutrons to split other U-235 atoms setting up a chain of explosions that may sweep through a block of U-235 releasing energy equivalent to 11,400,000 kilowatt-hours per pound.

We now have a man-made new element, number 94 with 145 neutrons, called plutonium which can also be split like U-235. In an elementary way, the principle of atomic explosion can be shown by a diagram:


U-235
Less than critical mass
Pieces well separated to prevent neutrons of one piece bombarding the other.
U-235
Less than critical mass
U-235
U-235

Bringing pieces together rapidly creates more than the critical mass thus starting an explosive chain reaction.

For items 155 - 164 select from the key the most appropriate response.

KEY

- **A.** The first part of the statement is true, and its truth is supported by the reason given in the statement.
- **B.** The first part of the statement is true, but its truth is *not* supported by the reason given in the statement.
- **C.** The first part of the statement is *false*.

155. (2.10) The atoms of all elements are neutral because the neutron has no electrical charge.

156. (2.10) Splitting uranium into other elements produces elements of slightly different atomic weights because some neutrons are given off in the action.

157. (2.10) Plutonium is listed as element 94 because it has 94 electrons.

158. (2.10) U-238 has the same atomic weight as U-234 because U-234 is an isotope of U-238.

159. (2.10) Electrons have no electrical attraction for the nucleus because atoms are neutral in charge.

160. (2.10) Plutonium is heavier than U-238 as evidenced by its greater atomic weight.

161. (2.10) The chance of a direct hit on the nucleus by an electron bullet is good because the atom is mostly empty space.

162. (2.10) Centripetal force keeps electrons in their orbits because electrons travel at high speed around the nucleus.

163. (2.10) The separation of U-235 and U-238 is most likely done by physical means because they are chemically the same element.

164. (2.10) Ordinary chemical reactions do not affect the nucleus because the protons and neutrons are held tightly together.

Items 165 - 173. The Atomic Pile for the Production of Pu-239.

A pile is made of layers of U-238, graphite bars, and cadmium bars. High energy neutrons are slowed by the carbon moderators and thus are ready for absorption by the atoms of U-238. A compound of hydrogen might serve as the moderator but for the fact that hydrogen atoms tend to trap neutrons and become heavy hydrogen atoms.

In symbols the nuclear reactions are:

$$\mathbf{U}_{92}^{238} + {}_{0}^{1}\mathbf{n} = \mathbf{U}_{92}^{239}$$
$$\mathbf{U}_{92}^{239} = e + \mathrm{Np}_{93}^{239} + \text{energy}$$
$$\mathrm{Np}_{93}^{239} = e + \mathrm{Pu}_{94}^{239}$$

If the neutron concentration becomes too high as shown by neutron counters placed within the pile the condition is corrected by insertion of Cd bars. An outside continuous source of neutrons is not required because neutrons are supplied by fission of some of the U-235 atoms and by fission of some of the newly formed Pu-239 (the product of the pile).

165. (2.10) To be accepted into the nucleus by Uranium-238, neutrons must be

A. fast. **B.** energetic. **C.** hot. **D.** slow.
E. fresh from an outside source.

166. (2.10) Np_{93}^{239} which is formed first, must be converted to Pu_{94}^{239} by

A. bombardment with more neutrons.
B. bombardment with deuterons.
C. bombardment with alpha particles.
D. allowing it to undergo natural radioactive decay.
E. chemical treatment.

167. (2.10) Of the particles and nuclei listed in symbols above, the one which is an isotope of U-238 is

A. Pu_{94}^{239}. **B.** electron. **C.** Np_{93}^{238}.
D. U_{92}^{238}. **E.** U_{92}^{239}.

168. (2.10) After the reaction has started, it is kept going by neutrons supplied in part by

A. an outside source. **B.** Np-239. **C.** Pu-239.
D. U-234. **E.** U-239.

169. (2.10) Pu-239 is produced at an increasingly rapid rate because

A. as in the fission of U-235, the fission of Pu-239 releases 3 neutrons.
B. in addition to the main reaction there are certain side reactions that produce Pu-239.
C. no Pu-239 atoms are lost once they are formed.
D. presence of Cd stabilizes and prevents decay of the Pu-239.
E. presence of carbon stabilizes and prevents decay of the Pu-239.

170. (2.10) Hydrogen nuclei tend to trap neutrons because of the tendency to form

A. alpha particles. **B.** positrons.
C. gamma rays. **D.** deuterons. **E.** beta rays.

171. (2.10) The use of cadmium in the pile is to

A. make the neutrons go faster. **B.** absorb heat.
C. remove neutrons.
D. interfere with the action of the graphite.
E. convert the neutrons to alpha particles.

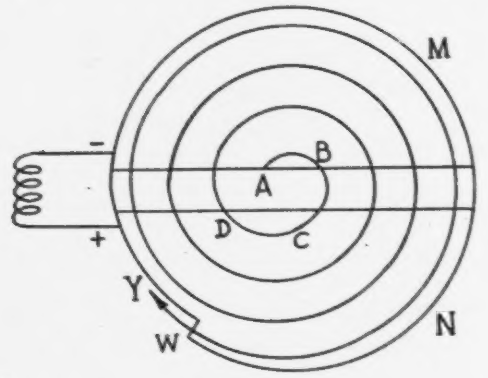
172. (2.10) The first atomic pile was set into operation by

A. Fermi. **B.** Rutherford. **C.** Seaborg.
D. Nier. **E.** Joliot.

173. (2.10) When U-239 changes to nP-239, the electron comes from

A. an orbital electron. **B.** a nuclear proton.
C. a nuclear alpha particle. **D.** a nuclear neutron.
E. a nuclear deuteron.

Items 174 - 183. Read the following paragraphs carefully. You may read the paragraphs as often as you wish while answering the items.



A cyclotron looks like a flat, round box several feet in diameter and about two inches high—mounted horizontally between the poles of a large electromagnet (one pole is above the box and one under), so that the lines of magnetic force traverse the box vertically. The box is cut across a diameter into two semi-cylinders, called "dees" because each is shaped like the letter D.

These two semi-cylinders are pulled apart, so that there is a two-inch gap between them. These dees are connected to a device which produces alternating electric current of very high frequency. One dee is negatively charged electrically while the other is positively charged, and these charges are alternated millions of times per second.

A gaseous positive ion, for example a deuteron ${}_{1}^{2}\mathrm{H}+$, produced near A, is attracted toward the negatively charged dee labeled M in the diagram. Once inside this dee, it is moving in a practically constant electric field (negative charge on all sides), so that its speed is then constant; but because of the magnetic field its path is circular. The electric field reverses as the ion travels from A to B, so that dee M becomes positive and dee N becomes negative; hence the ion is accelerated across the gap (repelled from behind and attracted ahead). It then travels from C to D inside dee N. Meanwhile the electric field again reverses, and the ion again gains speed in crossing the gap.

The faster the ion goes, the more difficult it is for the magnet to force it into a circular path. As a result the particle describes increasingly larger semi-circles. The ion spirals outward with continually increasing speed until, finally, at enormous speed it flies out of the apparatus at W, and at Y it strikes the atoms which are to be broken apart.

After the number on the answer sheet corresponding to that of each statement, blacken space

A. if the statement is true, and its truth is supported by information given in the selection.
B. if the statement is true, but its truth is *not* supported by information given in the selection.
C. if the statement is false, and its falsity is shown by information given in the selection.
D. if the statement is false, but its falsity is *not* shown by information given in the selection.

174. (2.10) If it were not for the magnetic field an ion moving from B to C would continue in a straight line.

175. (2.10) An ion in the cyclotron is subjected to an intermittent accelerating force.

176. (2.10) The heavier the ion, the more its path will be deflected by a magnetic field.

177. (2.10) A deuteron colliding with an ordinary sodium atom ${}_{11}^{23}\mathrm{Na}$ at Y will change it to an atom of radioactive sodium, ${}_{11}^{24}\mathrm{Na}$. In addition a proton is formed.

178. While moving from C to D the velocity of an ion
(2.10) increases.

179. The more intense the magnetic field, the greater will be
(2.10) the deflection of the path of an ion from a straight line to a circular path.

180. The reversing electric field causes the ions to move
(2.10) faster and faster.

181. The cyclotron was invented by Ernest O. Lawrence of
(2.10) the University of California.

182. In the cyclotron, a neutron traveling at high speed from
(2.10) B to C would also pass through D.

183. The motion of an ion from W to Y is constant in velocity.
(2.10)

Items 184 - 186. Consider the following five nuclear reactions:

A. ${}_{92}U^{238} + {}_0n^1 = {}_{36}Kr^{90} + {}_{55}Cs^{146} + {}_1H^2 + {}_0n^1$.
B. ${}_{94}Pu^{239} + {}_0n^1 = {}_{38}Sr^{96} + {}_{56}Ba^{141} + 3{}_0n^1$.
C. ${}_{92}U^{238} = {}_{90}Th^{234} + {}_2He^4$.
D. ${}_1H^3 + {}_1H^2 = {}_2He^4 + {}_0n^1$.
E. ${}_{47}Ag^{107} + {}_0n^1 = {}_{47}Ag^{108} = {}_{48}Cd^{108} + {}_{-1}e^0$.

Indicate, l narking the appropriate space on the answer sheet, which one

184. represents a fission reaction which can be activated by
(2.10) slow neutrons.

185. represents a fission reaction which cannot be activated
(2.10) by slow neutrons.

186. represents a fusion reaction which would yield large
(2.10) amounts of energy.

187. In the nuclear reaction: ${}_{12}Mg^{24} + {}_1H^2 = (\quad) + {}_2He^4$,
(2.10) the missing particle is

A. ${}_{11}Na^{23}$. **B.** ${}_{11}Ne^{22}$. **C.** ${}_{10}Na^{22}$.
D. ${}_{10}Ne^{21}$. **E.** ${}_{11}Na^{22}$.

188. In the nuclear reaction: ${}_{13}Al^{27} + {}_2He^4 = {}_{14}Si^{30} + (\quad)$,
(2.10) the missing particle is

A. an alpha particle. **B.** a beta+.
C. a beta−. **D.** a proton. **E.** a neutron.

Items 189 and 190 refer to the following equation for a fission type reaction:

$${}_0n^1 + {}_{92}U^{235} \rightarrow {}_{57}La^{140} + {}_xD^{80} + (x)\ {}_0n^1$$

189. The atomic number of element D is
(2.10)

A. 92. **B.** 56. **C.** 46. **D.** 36. **E.** 35.

190. The number, (x), of neutrons produced in the reaction
(2.10) is

A. 16. **B.** 15. **C.** 10. **D.** 1. **E.** 0.

Items 191 - 193 refer to the following transmutation reaction:

$${}_{26}Fe^{54} + {}_1H^2 \rightarrow {}_2He^4 + {}_xE^{52}.$$

191. The bombarding particle (${}_1H^2$) is a (an)
(2.10)

A. positron. **B.** proton. **C.** deuteron.
D. alpha particle. **E.** electron.

192. The particle produced (${}_2He^4$) is a (an)
(2.10)

A. positron. **B.** proton. **C.** deuteron.
D. alpha particle. **E.** electron.

193. Element E is
(2.10)

A. iron. **B.** manganese. **C.** cobalt.
D. chromium. **E.** nickel.

Items 194 and 195 refer to the following transmutation equation:

$${}_6C^{13} + {}_1H^1 \rightarrow {}_7N^x + {}_0n^1.$$

194. The bombarding particle is a (an)
(2.10)

A. positron. **B.** proton. **C.** deuteron.
D. alpha particle. **E.** electron.

195. The atomic weight, (x), of the nitrogen is
(2.10)

A. 21. **B.** 19. **C.** 14. **D.** 13. **E.** 12.

196. Carbon serves as a moderator in the atomic pile. It cap-
(2.10) tures a few neutrons according to the following equation:

$${}_6C^{12} + {}_0n^1 \longrightarrow {}_6C^{13}.$$

The most important use of this product is for

A. producing very hot flames.
B. making atom bombs. **C.** curing cancer.
D. making artificial diamonds.
E. a tracer element in chemistry.

Items 197 - 199 refer to the following equation for a simple capture type of nuclear reaction:

$${}_6C^{12} + {}_1H^1 \rightarrow N.$$

197. The atomic number of the nitrogen produced would be
(2.10)

A. 5. **B.** 7. **C.** 8. **D.** 11. **E.** 13.

198. The atomic weight of the nitrogen produced would be
(2.10)

A. 5. **B.** 7. **C.** 8. **D.** 11. **E.** 13.

199. The carbon is being bombarded with a (an)
(2.10)

A. proton. **B.** deuteron. **C.** alpha particle.
D. beta particle. **E.** neutron.

Items 200 - 203 represent changes involving the nuclei of atoms. After each item number on the answer sheet, blacken the *one* lettered space which designates the correct answer, choosing your answer from the group of answers at the right.

200. ${}^{239}_{92}U \rightarrow X + e^-$.
(2.10)

201. ${}^{239}_{93}Np \rightarrow X + e^-$.
(2.10)

202. ${}^{238}_{92}U$ + neutron $\rightarrow X$.
(2.10)

203. ${}^{238}_{92}U \rightarrow {}_2He^4 + X$.

A. if X is ${}^{239}_{94}X$.
B. if X is ${}^{234}_{90}X$.
C. if X is ${}^{239}_{93}X$.
D. if X is ${}^{242}_{94}X$.
E. if X is ${}^{239}_{92}X$.

For items 204 - 209, select your answer from the list of nuclear reactions at the right.

204. ${}^{238}_{92}U + {}^4_2He \rightarrow {}^1_0n + X$.
(2.10)

205. $X + {}^4_2He \rightarrow {}^1_0n + {}^{242}_{96}Cm$.
(2.10)

206. ${}^{238}_{92}U + {}^1_0n \rightarrow {}^{239}_{92}U \xrightarrow{e^-}$
(2.10) ${}^{239}_{93}Np \xrightarrow{e^-} X$.

207. ${}^{238}_{92}U + {}^2_1H \rightarrow 2{}^1_0n + X$.
(2.10)

208. ${}^{239}_{94}Pu + {}^4_2He \rightarrow X + {}^1_0n$.
(2.10)

209. ${}^{242}_{95}Am \rightarrow e^- + X$.
(2.10)

A. if X is ${}^{242}_{96}Cm$.
B. if X is ${}^{241}_{94}Pu$.
C. if X is ${}^{240}_{96}Cm$.
D. if X is ${}^{239}_{94}Pu$.
E. if X is ${}^{238}_{93}Np$.

Items 210 - 213. Radioactive sodium can be obtained from ordinary sodium by the following nuclear reaction:

$${}^{23}_{11}Na + {}^{2}_{1}H \rightarrow {}^{24}_{11}Na + {}^{1}_{1}H.$$

210. The particle used in causing the change shown above
(2.10) is

A. a neutron. **B.** an alpha particle.
C. a proton. **D.** a deuteron. **E.** a beta particle.

211. This particle is usually obtained through use of a
(2.10)

A. cyclotron. **B.** cloud chamber.
C. mass spectrograph. **D.** uranium pile.
E. radioactive element found in nature.

212. The particle formed in addition to the radioactive sodium
(2.10) is

A. an alpha particle. **B.** an electron.
C. a neutron. **D.** a deuteron. **E.** a proton.

213. The atomic weight of the radioactive element is
(2.10)

A. 11. **B.** 23. **C.** 24. **D.** 12.
E. none of these.

Items 214 - 222. After the number on the answer sheet corresponding to that of each of the numbered nuclear reactions at the right, blacken the *one* lettered space which indicates the correct substitute for "X."

A. if X is ${}_7N^{13}$.
B. if X is ${}_9F^{17}$.
C. if X is ${}_8O^{15}$.
D. if X is ${}_6C^{14}$.
E. if X is ${}_7N^{16}$.

214. ${}_7N^{15} + {}_1H^2 \rightarrow X + {}_1H^1$.
(2.10)

215. ${}_8O^{16} + On^1 \rightarrow X + 2On^1$.
(2.10)

216. ${}_6C^{12} + {}_1H^2 \rightarrow X + On^1$.
(2.10)

217. ${}_9F^{19} + On^1 \rightarrow X + {}_2He^4$.
(2.10)

218. ${}_7N^{14} + On^1 \rightarrow X + {}_1H^1$.
(2.10)

219. ${}_8O^{16} + {}_1H^1 \rightarrow {}_0\delta^0 + X$.
(2.10)

220. ${}_7N_1{}^4 + {}_2He^4 \rightarrow X + On^1$.
(2.10)

221. ${}_8O^{16} + {}_0\delta^0 \rightarrow X + On^1$.
(2.10)

222. ${}_7N^{14} + {}_1H^2 \rightarrow X + {}_1H^3$.
(2.10)

223. The sun radiates a large amount of energy as a result of
(2.20) the union of four hydrogen atoms to form the helium atom. The reason for this release of energy is that

A. the hydrogen atoms are in a high state of thermal excitation.
B. the coulomb forces of attraction between the nuclei of the hydrogen atoms are large.
C. the mass of the helium atom is less than the mass of the four hydrogen atoms.
D. large numbers of neutrons are released during the formation of the helium atom.
E. gamma rays released in this process have very high energy.

224. The observation that, while cathode rays are repelled by
(2.20) a negative charge and deflected at right angles to the lines of a magnetic field, X-rays show no change in direction in either kind of field, is ready proof that

A. X-rays, themselves, carry no charge.
B. the relatively high speed of the X-rays nullify the effects of any charge or field.
C. X-rays carry a charge of both positively and negatively charged ions.
D. X-rays are really a stream of electrons.
E. X-rays are really a stream of negatively-charged particles.

Items 225 - 230 refer to the following paragraph (George W. Gray, "The Alternate Particles," *Scientific American*, June, 1948).

The cloud chamber operates by a simple scheme in which the moisture-laden air within it is suddenly cooled by the withdrawal of a piston that expands the volume of the chamber. If a charged particle darts through the chamber at the moment of this expansion, droplets of the supersaturated vapor attach themselves to the air molecules which have been mutilated by collision with the particle, and thus the course of the speeding particle is revealed as a track of cloud. The physicist is able to get additional information by placing the cloud chamber between the poles of a magnet.

225. A suitable charged particle for darting through the
(1.30) cloud chamber might be

A. a molecule of water vapor. **B.** a neutron.
C. a cyclotron. **D.** an atom of argon.
E. an electron.

226. Mutilation of the air molecules might consist of
(1.30)

A. nuclear fission.
B. a rearrangement of the electron shells.
C. knocking off an electron.
D. activation of the nucleus.
E. knocking off a proton.

227. The cloud track forms as the piston is raised because
(2.20)

A. condensation nuclei have been formed by the charged particle.
B. it is always associated with charged particles just as the tail always accompanies a comet.
C. the speeding charged particle leaves a vacuum behind it into which the water vapor rushes to form a cloud.
D. of the electrostatic force exerted by the charged particle on water molecules.
E. raising the piston is a cloud forming process and the fact that a charged particle is there is purely coincidental.

228. The withdrawal of a piston cools the air in the cloud
(2.20) chamber because

A. the resulting condensation of vapor to form cloud tracks is a heat absorbing process.
B. air is always cooler when the molecules are far apart than when they are close together.
C. the air molecules assist in moving the piston and do work against intermolecular forces.
D. there are fewer collisions between molecules in the air after the volume is increased.
E. temperature and density of a gas are directly proportional if the mass is constant.

229. Droplets of supersaturated vapor are present because
(2.20)

A. the air has a very low relative humidity before expansion.
B. solubility of water vapor in air rises with increase in temperature.
C. more water must have been added to the chamber simultaneously.
D. of the action of the charged particle which darts through the chamber.
E. the increased volume permits increased evaporation into the air.

230. By placing the cloud chamber between the poles of a
(1.25) magnet the physicist could learn the

A. size of the particle.
B. nature of the charge on the particle.
C. structure of the particle.
D. viscosity of the air-water vapor mixture.
E. speed, mass, and energy of the particle.

231. Short wave broadcast is heard in the United States from
(2.40) Europe, even though the path is not a straight line because

A. radio waves travel in a curved path.
B. radio waves travel through the outer layer of the lithosphere.
C. radio waves are reflected by upper layers of the atmosphere.
D. radio waves are bent by the earth's magnetic field.
E. radio waves travel through the air only and therefore cannot get out of the atmosphere.

For items 232 - 235 use the following key.

In the early days of cathode-ray study, during the process of experimentation, the results listed below were noted. These results gave rise to certain inferences. From the key of inferences given below, select the one that would be *most likely* to arise as a result of the evidence or experimental result described in each item.

Key of Inferences

A. Cathode rays possess considerable kinetic energy.
B. Cathode rays possess considerable potential energy.
C. Cathode radiation travels approximately in straight lines.
D. Cathode radiation carries a strong negative charge.
E. Cathode radiation carries a strong positive charge.

232. Experiments showed that obstacles in the path of cath-
(2.40) ode rays produced sharp shadows.

233. Experiments showed that a piece of platinum placed at
(2.40) the point where the rays converged, quickly became red-hot.

234. Experiments showed that the rays can be focused on a
(2.40) point by using a cathode with a concave surface, somewhat as light is focused, by a concave mirror.

235. Experiments showed that if a tiny paddle wheel is
(2.40) placed on a runway in the tube, with the vanes in the path of the rays—it will move rapidly away from the cathode.

Items 236 - 243. After each exercise number on the answer sheet, blacken the *one* lettered space which designates the correct answer.

$$^{238}_{92}U \xrightarrow{\alpha} UX_1 \xrightarrow{\beta} UX_2.$$

236. The uranium atom is radioactive, emitting an alpha-
(3.00) particle to become a new atom UX_1. The atomic number of UX_1 is

A. 94. **B.** 92. **C.** 91. **D.** 90. **E.** 88.

237. The basis for the above prediction is
(3.00)

A. the alpha-particle has a charge of two positive units.
B. the alpha-particle has no charge.
C. the alpha-particle has a charge of one positive unit.
D. the alpha-particle has a mass of four units.
E. the alpha-particle has a charge of two negative units.

238. The atomic weight of UX_1 is
(3.00)

A. 240. **B.** 238. **C.** 237. **D.** 236. **E.** 234.

239. The basis for the above prediction is that the alpha-
(3.00) particle has

A. a charge of two negative units. **B.** no charge.
C. a mass of two units. **D.** a mass of four units.
E. a mass negligible to that of the uranium atom.

240. The atom UX_1 emits a beta-particle, forming a new
(3.00) atom, UX_2. The atomic number of UX_2 is

A. 92. **B.** 91. **C.** 901. **D.** 89. **E.** 88.

241. The basis for the above prediction is that the beta-
(3.00) particle has

A. no charge.
B. a charge negligible compared with that of the nucleus of the UX_1 atom.
C. a mass negligible compared with that of the UX_1 atom.
D. a charge of one negative unit.
E. a charge of two negative units.

242. The atomic weight of UX_2 is
(3.00)

A. 240. **B.** 238. **C.** 237. **D.** 236. **E.** 234.

243. The basis for the above prediction is that the beta-
(3.00) particle has

A. no charge.
B. a charge negligible compared with that of the nucleus of the UX_1 atom.
C. a mass negligible compared with that of the UX_1 atom.
D. a charge of one negative unit.
E. a charge of two negative units.

244. In the nuclear disintegration $_7N^{14} + {}_1H^1 = C + {}_2He^4$
(3.00)

A. the carbon atom produced will have a mass of 11 and an atomic number of 6.
B. the carbon atom produced will have a mass of 12 and an atomic number of 5.
C. the carbon atom produced will have a mass of 12 and an atomic number of 6.
D. none of the above statements is true.

245. An element of Group VI with atomic weight 238 and
(3.00) atomic number 92 emits in succession an alpha particle, a beta particle, a beta particle and an alpha particle. The resultant atom must have

A. atomic weight of 230, atomic number 90 and be in Group IV.
B. atomic weight of 232, atomic number 92 and be in Group V.

C. atomic weight of 228, atomic number 90 and be in Group VI.
D. atomic weight of 230, atomic number 88 and be in Group IV.
E. atomic weight of 230, atomic number 92 and be in Group VI.

246. (3.00) Electrons in an electron microscope are traveling with a velocity of 2×10^9 cm./sec. Assuming the mass of an electron to be 9×10^{-28} gm. and Planck's constant to be 6×10^{-27} erg. Sec., the wavelength of the electron is

A. 0.33 A. **B.** 1.33×10^{-8} cm. **C.** 3 A.
D. 3×10^8 cm. **E.** 108×10^{-38} A.

247. (3.00) Find the maximum velocity of a photoelectron which can be stopped by 3 volts negative potential. (Assume $\frac{e}{m} = 5 \times 10^{17}$ e.s.u./gm. for the electron and 1 volt $= \frac{1}{300}$ e.s.u. of potential.)

A. 10^7 cm/sec. **B.** 10^3 cm/sec. **C.** 10^9 cm/sec.
D. 10^{10} cm/sec. **E.** 3×10^{10} cm/sec.

248. (3.00) Two energy levels within an atom differ by 3×10^{-12} erg. Assuming Planck's constant to be 6×10^{-27} erg-sec, the radiation emitted when an electron jumps from one of the levels to the other is

A. in the infra-red. **B.** a gamma ray.
C. visible. **D.** an X-ray. **E.** in the ultra-violet.

For items 249 - 258 use the following key:

A. The statement is *true* but the reason is *false.*
B. The statement is *false* but the reason is *true.*
C. The statement is *true* and the reason is *true.*
D. The statement is *false* and the reason is *false.*

249. (4.20) ( ) Low voltage X-rays are more dangerous than high voltage X-rays because they carry more energy.

250. (4.20) ( ) High voltage X-rays have great penetrating power because they are high energy rays.

251. (4.20) ( ) Scientists knew that if barium was produced by neutron bombardment of uranium that fission had been attained, because a lighter element had been made from a heavier one.

252. (4.20) ( ) Scientists knew that in a fission reaction if one neutron caused the release of more than one neutron, a chain reaction would result, because the released neutrons certainly would bring about fission in other atoms.

253. (4.20) ( ) It is known that under certain conditions of energy, neutrons will bring about fission in any element because the binding energy value of all nuclei is the same.

254. (4.20) ( ) Gamma rays are more dangerous to the personnel of a nuclear reaction plant than are the beta rays because they are made up of positively charged particles.

255. (4.20) ( ) The isotopes of an element cannot be separated from each other by chemical methods, because the atomic number of an element is somewhat responsible for an element's chemical behavior and all the isotopes of an element have the same atomic number.

256. (4.20) ( ) A molecule of heavy water weighs more than a molecule of ordinary water because of the alpha particles in its nucleus.

257. (4.20) ( ) When a neutron is projected into the nucleus of a U-238 atom, it causes the atom to change immediately into a plutonium atom because in a nuclear reactor plutonium is obtained from neutrons bombarding U-238.

258. (4.20) ( ) Graphite is used as a moderator in a nuclear reactor because graphite is an excellent absorber of neutrons.

18. Light

LIGHT

1. (1.10) Which of these wave forms will travel through a vacuum?

A. Light. **B.** Sound. **C.** Electromagnetic waves.
D. Two of the above. **E.** All of the above.

2. (1.10) In nearsightedness the

A. lens of the eye is concave.
B. image would form behind the retina.
C. pupil of the eye is too convex.
D. focal length of the lens is too short.
E. lens is more convex in one plane than another.

3. (1.10) A white ceiling aids in the illumination of a room because of

A. absorption. **B.** refraction.
C. diffused reflection. **D** polarization.
E. diffraction.

4. (1.10) In general, when molecules rather than atoms are excited, the type of spectrum produced is

A. continuous. **B.** band. **C.** bright line.
D. Fraunhofer. **E.** absorption.

5. (1.10) A virtual image

A. is always inverted with respect to the object.
B. is always smaller than the object.
C. is always larger than the object.
D. can be formed only by a plane mirror.
E. is formed by the apparent focusing of light rays.

6. (1.10) In near-sightedness, the distance from the lens system to the retina of the eyeball is too

A. short and needs a converging lens for correction.
B. short and needs a diverging lens for correction.
C. short and needs a tinted lens for correction.
D. long and needs a diverging lens for correction.
E. long and needs a converging lens for correction.

7. (1.10) A foot candle is a measure of the

A. power from a light source.
B. light from a candle 1 ft. long.
C. heat received from a standard candle.
D. intensity of illumination on a surface.
E. candle power of a source of light.

Indicate the appropriate type of lenses from the list below.

A. Convex or converging lenses.
B. Concave or diverging lenses.
C. Neither of the above. **D.** Both of the above.

		Discr.	Difficulty
8. (1.10)	Used to correct vision.	.44	76%
9. (1.10)	Produces an enlarged, erect image under certain conditions.	.11	37%
10. (1.10)	Lenses that are thinner at the center than at the edge.	.53	70%
11. (1.10)	Used to correct nearsightedness.	.27	59%

12. (1.10) Parallel beams of light are best diffused by a

A. glass prism. **B.** a mirror.
C. a rough white object. **D.** a rough black object.
E. a smooth white object.

Indicate the appropriate terms from the list below to correctly fill this blank.

A. If the blank would best be filled by reflection.
B. If the blank would best be filled by refraction.
C. If the blank would best be filled by diffraction.
D. If the blank would best be filled by interference.
E. If the blank would best be filled by the Doppler effect.

13. (1.10) Beats are due to________.

14. (1.10) Echoes are an example________.

15. (1.10) All lenses bend light by________.

16. (1.10) We see the sun after it has set below the horizon for a short, time, because of the ________ of light by the atmosphere.

17. (1.10) A passenger in an airplane does not hear the same pitch of the engine as the friend whom he leaves behind at the airport because of________.

18. (1.10) When water waves pass through a small opening in a breakwater, the waves going through become curved about the opening as a center. This is due to________.

19. (1.10) A stick partly immersed in water appears bent because of________.

20. (1.10) The colors of the rainbow can often be seen when the sun's rays pass through the water spray from a lawn sprinkler because of ________ of light.

21. (1.10) The familiar mirage on the desert is due to the ________ of light.

22. (1.10) All of the following which concern a virtual image formed by any single lens are correct except that

A. it is always erect.
B. it is always on the same side of the lens as the object.
C. it is always smaller than the object.
D. it is always formed so that the light seems to come from the image.
E. All of the above are correct.

23. (1.10) The color effect of the rainbow in the sky is due to

A. reflection. **B.** an optical illusion.
C. refraction. **D.** interference. **E.** diffraction.

24. (1.10) Rays of light which pass through a lens obliquely from an object point remote from the principal axis and do not converge upon a common image point, produce a defect known as

A. chromatic aberration. **B.** spherical aberration.
C. astigmatism. **D.** nearsightedness.
E. farsightedness.

Select the one correct or best answer.

25. (1.10) The equivalent focal length of the optical system in the human eye is about 2 cm. The most important factor responsible for this short distance is

A. the shape of the retina. **B.** the position of the iris.
C. the size of the pupil.
D. the size of the curvature of the crystalline lens surfaces.
E. the interdependence of the two eyes.

26. (1.10) The focusing adjustment of the human eye for near and far objects is a function of the

A. rods and cones. **B.** iris. **C.** pupil.
D. crystalline lens. **E.** transparent cornea.

27. (1.10) Accommodation in the eye is

A. the adjustment to changes in the brightness of the light.
B. the focusing of the eye by changes in the lens thickness.
C. the discrimination of colors by the eye.
D. the interpretation of the inverted image on the retina as an erect one by the brain.
E. the correction with lenses of nearsightedness or farsightedness.

Items 28 to 31 refer to defects of lenses of the eye. For each item select from the key the correct name for the defect.

KEY

A. Astigmatism. **B.** Near-sightedness.
C. Spherical aberration. **D.** Chromatic aberration.
E. None of these.

28. (1.10) All wave lengths in a beam of light may not come to the same focus after passing through the lens.

29. (1.10) A lens may have greater convexity in one plane than another.

30. (1.10) Light through a lens may come to a focus at greater than normal distance from the lens.

31. (1.10) Rays of light parallel to the principal axis of a lens which pass through its edges, do not come to the same focus as those through the center.

Indicate the associated term from the list below.

A. Astigmatism. **B.** Nearsightedness
C. Farsightedness. **D.** None of these.

32. (1.10) Light from a distance focuses in front of the retina of the eye.

33. (1.10) There is unequal curvature in the different planes of the lens of the eye.

34. (1.10) Astigmatism may be explained as

A. due to the greater convexity of the lens of the eye in one plane than another.
B. the formation of an image behind the retina.
C. the formation of an image in front of the retina.
D. the dispersive effect of the eye lens.
E. the lack of sharp focus of rays parallel to the axis of the eyes, which enter near the edge of the lens.

Items 35 - 37 deleted.

For items 38 to 40 select from the key the term which would most appropriately fill the blank in the item.

KEY

A. Reflection. **B.** Refraction. **C.** Diffraction.
D. Interference. **E.** The Doppler effect.

38. (1.10) Light passing by a straight edge is bent into the geometrical shadow by________.

39. (1.10) Apparent changes in the wave length of light coming from beyond the solar system are evidence of________.

40. (1.10) The angle of incidence always equals the angle of ________.

41. (1.10) In a simple astronomical telescope which is focused on a distant object

A. the objective lens forms an image in the plane of its focal distance.
B. the eyepiece forms a real image.
C. the focal length of the objective is less than that of the eyepiece.
D. the image formed by the objective lens is enlarged.
E. the final image formed by the telescope is erect.

Items 42 to 47 refer to properties of wave motion. For each item select from the key the most appropriate response.

KEY

A. Diffraction. **B.** Dispersion. **C.** Reflection.
D. Refraction. **E.** None of the above.

42. (1.10) Objects seen through ordinary window glass are frequently distorted.

43. (1.10) Sounds may be readily heard around the corner of a building when the source is invisible.

44. (1.10) The depth of a stone in water is greater than it appears.

45. (1.10) Spectra of stars frequently show a "red shift."

46. (1.10) Acoustics of an empty auditorium are poorer than when an audience is present.

47. (1.10) Something a "color corrected" camera lens is designed to prevent.

48. (1.10) With a converging lens it is impossible to obtain a

A. virtual image smaller than the object.
B. magnified real image.
C. real image the same size as the object.
D. real image one-half the size of the object.
E. virtual image which is magnified.

49. (1.10) The magnifying power of a telescope

A. depends upon the diameter of the lenses used.
B. depends entirely upon the focal length of the eyepiece.
C. is changed if a negative lens of equal focal length is used in place of a converging eyepiece.
D. is a ratio of the focal length of the objective to that of the eyepiece.
E. depends upon the magnitude of the object distance.

50. (1.10) Which one of the following statements, concerning either the use of or characteristics of using a movie film with a projecting lens, is correct?

A. The film is placed between the lens and its principal focus on the side toward the light source.

B. The film is placed exactly at the principal focus of the lens.
C. The film is a negative but shows on the screen as a positive.
D. The film is placed at a distance slightly greater than the focal length of the lens.
E. The light through the film is continuously thrown on the projection screen.

51. (1.10) A narrow beam of light strikes a rectangular plate of glass at an acute angle and passes through the glass. Which one of these statements is true?

A. The emergent ray is in the same straight line as the incident ray.
B. The incident ray bends away from the perpendicular upon entering the glass.
C. The sine of the angle of incidence will equal the sine of the angle of refraction.
D. The emergent ray bends away from the perpendicular.
E. The direction of the emergent ray has no relation to the direction of the incident ray.

52. (1.10) Which one of these terms is essential to your vocabulary in discussing the nature of light waves?

A. Rarefaction. **B.** Compressional.
C. Transverse. **D.** Material medium.
E. Longitudinal.

53. (1.10) A person wading in water looks ahead at the bottom. The bottom looks shallower than it is because the light from the bottom is

A. reflected. **B.** refracted. **C.** magnified.
D. diffracted.
E. acted upon by some phenomonon other than one of the above four.

54. (1.10) A virtual image is one

A. which is always inverted.
B. in which the image is smaller than the object.
C. in which the light seems to come from the image.
D. which can be formed only by a plane mirror.
E. which can be shown on a screen.

Item 55 deleted.

56. (1.10) A phenomenon that may change the wave length of light coming from beyond the solar system is

A. reflection. **B.** refraction. **C.** interference.
D. diffraction. **E.** the Doppler effect.

57. (1.10) Chromatic aberration in a single lens is *best* explained by the statement:

A. The angle of refraction depends upon the wave length.
B. The refractive power varies greatly with the kind of glass used.
C. Light travels more slowly through glass than air.
D. A lens absorbs some colors better than others.
E. The angle of incidence affects the angle of refraction.

58. (1.10) Which one of these is *false* concerning a virtual image formed by any single lens?

A. It is always erect.
B. It is always on the same side of the lens as the object.
C. It is always smaller than the object.
D. It is always formed so that the light seems to come from the image.
E. None of the above.

For items 59 - 61 use the key in this manner. If the item is true, mark 1 on the answer sheet, but if it is false, mark space 2, 3, 4 or 5 to show which word should be substituted for the word in parenthesis to make the statement true.

KEY

1. True. 2. Refracts. 3. Reflects.
4. Transmits. 5. Absorbs.

59. (1.10) A red rose (absorbs) red light

60. (1.10) A black object (refracts) all wave lengths of light.

61. (1.10) A white object (transmits) all colors.

For items 62 - 66 select from the key the behavior of light on which the statement of the item depends.

KEY

A. Refraction. **B.** Interference. **C.** Diffraction.
D. Two of the above. **E.** None of the above.

62. (1.10) An optometrist selects on this basis a lens to correct nearsightedness.

63. (1.10) A red book looks red. **64.** (1.10) Stars twinkle.

65. (1.10) Oil films on water display colors.

66. (1.10) Finely ruled lines on glass may be used as a substitute for a prism to form a spectrum.

67. (1.10) When a student reported the wave length of light as a certain fraction of a centimeter, he could have been referring to any of these colors *except*

A. white. **B.** yellow. **C.** blue. **D.** green.
E. red.

68. (1.10) Color and other characteristics typical of each element are shown in the spectrum type known as

A. continuous. **B.** band. **C.** bright line.
D. Fraunhofer. **E.** absorption.

69. (1.10) An opaque white object owes its color largely to

A. absorption. **B.** refraction. **C.** dispersion.
D. diffraction. **E.** reflection.

70. (1.10) Which of these wave forms will travel through a vacuum?

A. Light. **B.** Sound. **C.** Hertzian.
D. Two of the above. **E.** All of the above.

Item 71 deleted.

72. (1.10) Light from the stars shows apparent changes in frequency because of

A. interference phenomena.
B. refraction by layers of air.
C. bending by diffraction. **D.** reflection.
E. relative motion.

73. (1.10)	The rate at which *light* travels through space is	**A.** greater than **B.** less than **C.** the same as	the rate at which *electro-magnetic waves* travel through space.
74. (1.10)	The wave-length of ***X-rays*** is	**A.** greater than **B.** less than **C.** the same as	the wave-length of *radio waves.*
75. (1.10)	The frequency of *ultraviolet* light is	**A.** greater than **B.** less than **C.** the same as	the frequency of *infra-red* light.
76. (1.10)	The velocity of *waves of ultra-violet light* in a vacuum is	**A.** greater than **B.** less than **C.** the same as	the velocity of *cosmic rays* in a vacuum.
77. (1.10)	The extend to which a prism bends *violet* light is	**A.** greater than **B.** less than **C.** the same as	the extent to which a prism bends *red* light.

78. (1.10) The chief difference between radio waves and light waves is with respect to

A. their velocities. **B.** their frequencies.
C. their nature of transmission. **D.** their amplitude.
E. more than one of the above.

79. (1.10) The biological and chemical effects of light (including the infra-red and ultra-violet) becomes more conspicuous in

A. the shorter wave lengths.
B. the longer wave lengths.
C. the intermediate wave lengths.
D. all wave lengths.
E. the wave lengths of visible light range only.

80. (1.10) A prism bends

A. red light more than infra-red light.
B. red light more than green light.
C. green light more than violet light.
D. violet light more than red light.
E. X-rays more than blue light.

81. (1.10) Which of the following was used in the first measurement of the velocity of light?

A. Distance to the moon.
B. The diameter of the earth's orbit.
C. Distance from the earth to the sun.
D. $E = mc^2$.
E. The inverse square law relating light's apparent intensity and its distance from the source.

82. (1.10) Light differs from sound chiefly in that it

A. does not obey the formula of V = wave length × frequency.
B. does not require a material medium for its transmission.
C. is not reflected. **D.** does not contain energy.
E. is not a wave phenomenon.

83. (1.10) Light of a single wave length cannot be

A. absorbed. **B.** dispersed. **C.** reflected.
D. refracted. **E.** re-enforced.

Items 84 to 90 refer to wave motion. For each item select from the key the most appropriate response.

KEY

A. Hertzian. **B.** Light. **C.** Sound.
D. Two of the above. **E.** All of the above.

84. (1.10) A wave in which the wave particles vibrate in the direction of wave propagation.

85. (1.10) A wave which is used to demonstrate dispersion.

86. (1.10) A wave which is *not* transmitted through a vacuum.

87. (1.10) A wave which can be used to demonstrate diffraction effects.

88. (1.10) A wave which transmits energy.

89. (1.10) A wave which has electromagnetic properties.

90. (1.10) A wave in which the wave particles execute simple harmonic motion.

91. (1.10) If a beam of light is bent away from the normal (perpendicular) erected at the point where it goes from one medium to another,

A. the velocity of the light is increased.
B. dispersion of colors must occur.
C. the material which it enters is more dense optically.
D. no change in velocity occurs upon refraction.
E. no refraction will occur because refraction requires that the light bends toward the normal.

92. (1.10) Which one of these is an incorrect statement concerning the index of refraction?

A. It is the ratio of the velocity of the incident light to that of the refracted light.
B. It is different for red light than blue light.
C. Its value for all gases is nearly 1.
D. It is the ratio of the angle of incidence to that of refraction.
E. $n = \frac{\sin i}{\sin_r}$

93. (1.10) Which one of the following is a correct definition of focal length for a converging lens?

A. The distance from the center of the lens to the center of the circle, an arc of which forms the boundary of the lens.
B. The distance between the lens and the image of that object formed by the lens.
C. The distance between the two surfaces of the lens at its thickest point.
D. The distance from the center of the lens to the point where all incident rays parallel to the principal axis converge after emergence.
E. None of the above; none is a correct definition.

94. (1.10) If you were instructed to pick out a positive lens of relatively long focal length which one of the following would you pick?

A. A lens just a little thinner in the middle than at the edges.
B. A microscope objective lens.
C. An eyepiece from a simple Galilean telescope.
D. A convex lens of slight curvature.
E. A lens decidedly thicker through the middle than the edges.

Items 95 to 97 refer to the applications of phenomena in wave motion. For each item select from the key the *most closely related* term.

KEY

A. Diffraction. **B.** Doppler effect.
C. Interference. **D.** Reflection. **E.** Refraction.

95. (1.10) A jeweler often uses this property to detect imitation diamonds.

96. (1.10) Light will bend around sharp corners.

97. (1.10) The color effect of thin oil film on a wet pavement.

98. (1.10) If you look at a very distant light source through the tiny slit formed by placing two of your fingers close together, the image of the source will be fuzzy or blurred. The best explanation of this involves,

A. diffraction. **B.** refraction. **C.** reflection.
D. accommodation in the eye. **E.** the Doppler effect.

99. (1.10) From the standpoint of practicability in planning the lighting of a room, which one of the following should command the greatest attention?

A. Candle power of the source.
B. Resistance of the filament.
C. Photoelectric effect. **D.** Brightness of the source.
E. Foot-candles of illumination.

100. (1.10) We see the majority of objects about us, because

A. they emit light. **B.** they reflect light.
C. they absorb light. **D.** they are close to us.
E. light travels in straight lines.

The numbers preceding the paired items in the exercise below refer to the corresponding numbers on the answer sheet. Considering each pair from the standpoint of quantity, blacken space

A if the item in Column I is greater than the item in Column II.
B if the item in Column II is greater than the item in Column I.
C if the two items are of essentially the same magnitude.

	Column I		*Column II*
101. (1.10)	Velocity of sound in cold air.	....	Velocity of sound in warm air.
102. (1.10)	Extent to which the medium affects the velocity of sound.	....	Extent to which either loudness or pitch affect the velocity of sound.
103. (1.10)	Extent to which the equation $V = f \times 1$ applies to sound waves.	....	Extent to which the equation $V = f \times 1$ applies to light waves.
104. (1.10)	Extent to which a dark-line spectrum indicates the presence of a cooler gaseous envelope surrounding a star.	....	Extent to which a bright-line spectrum indicates the presence of a cooler gaseous envelope surrounding a star.
105. (1.10)	Extent to which the phenomena of the photoelectric cell support the wave theory of light.	....	Extent to which the phenomena of the photoelectric cell support the corpuscular theory of light.
106. (1.10)	Rate at which light travels through space.	....	Rate at which electromagnetic waves travel through space.
107. (1.10)	Wave-length of X-rays.	....	Wave-length of radio waves.
108. (1.10)	Frequency of ultra-violet light.	....	Frequency of infra-red light.
109. (1.10)	Extent to which the interference phenomena of light support the wave theory of light.	....	Extent to which the interference phenomena of light support the corpuscular theory of light.
110. (1.10)	Velocity of sound in air.	....	Velocity of sound in water.
111. (1.10)	Extent to which a prism bends violet light.	....	Extent to which a prism bends red light.
112. (1.10)	Temperature of a star whose spectrum is predominantly red.	....	Temperature of a star whose spectrum is predominantly blue.

113. (1.10) A glass prism separates white light into its various colored components because

A. high frequency radiation is refracted more than the lower frequencies.
B. low frequency radiation is refracted more than the high frequencies.
C. violet light travels faster in glass than red light.
D. red light has more energy than violet light.
E. violet light has greater penetrating power than red light.

114. (1.10) A student used a spectroscope with a glass prism to observe the spectrum of a substance which emitted considerable radiation in the ultra-violet region. After experimenting for some time, he reported that the light source was not intense enough to show the lines. The apparatus was in perfect adjustment. His conclusion was

A. probably correct.
B. wrong, because he could not see ultra-violet radiation anyway.
C. wrong, because any light source would emit its characteristic radiation.
D. wrong, because a glass prism will not transmit ultra-violet radiation.
E. wrong, because he would need dark glasses to see anything.

115. (1.10) In the situation described in the preceding item, the student should

A. try again and readjust the apparatus.
B. replace the glass prism with one of blue glass.
C. replace the glass prism with one of rock salt.
D. replace the glass prism with one of quartz glass.
E. wear dark glasses.

116. (1.10) When light passes from air into water

A. the angles of refraction and incidence are equal.
B. its velocity increases.
C. it is completely absorbed by the water.
D. destructive interference causes it to change direction.
E. its velocity decreases.

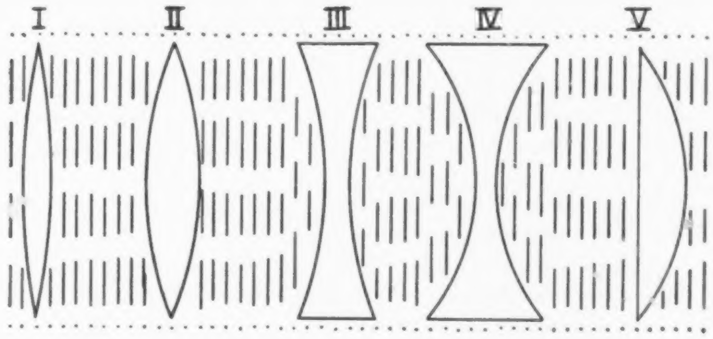
117. In a simple astronomical telescope which is focused on a
(1.10) distant object,

A. the image formed by the eyepiece is real.
B. the final image is erect.
C. the objective lens forms an image in its focal plane.
D. the objective lens forms an enlarged image.
E. the focal length of the objective lens is less than that of the eyepiece.

118. When a beam of light, of a single wave length, is directed against a very fine wire, the shadow formed or
(1.10) photographed back of it is not just that of a single wire but rather as if several wires were used. The best explanation of this involves

A. refraction. **B.** diffraction. **C.** reflection.
D. the Doppler effect. **E.** an optical illusion.

Items 119 and 120 refer to the following diagrams.



119. The lens best suited for the correction of extreme near-
(1.10) sightedness is

A. I. **B.** II. **C.** III. **D.** IV. **E.** V.

120. The lens with greatest focal length is
(1.10)

A. I. **B.** II. **C.** III. **D.** IV. **E.** V.

121. In general, when molecules rather than atoms are ex-
(1.10) cited, the type of spectrum produced is

A. continuous. **B.** band. **C.** bright line.
D. Fraunhofer. **E.** absorption.

122. A hot steam radiator can be photographed in complete
(1.10) darkness only if

A. the surface of the radiator is coated with aluminum paint.
B. a special wide-aperture lens is used.
C. infra-red sensitive film is used.
D. a very long exposure is made.
E. superheated steam is passed through the radiator.

123. A beam of white light from an incandescent lamp passes
(1.10) through relatively cool sodium vapor. What type of spectrum is likely to be formed?

A. A spectrum with a bright yellow region.
B. A spectrum with a bright double yellow line.
C. No spectrum except in the yellow region.
D. A spectrum with dark lines in the yellow region.
E. A continuous band with yellow lines interspersed throughout.

124. Separate beams of sunlight pass through red-colored
(1.10) glass and clear glass respectively. The red glass becomes hotter because

A. red light is converted into heat in the red glass.
B. ultra-violet light is transmitted by the red glass.
C. all other colors are reflected by the red glass.
D. red light is hotter than all of the other colors.
E. the colors absorbed by the red glass are converted into heat.

125. A narrow beam of light strikes a rectangular plate of
(1.10) glass at an acute angle and passes through the glass. Which one of these statements is true?

A. The emergent ray is in the same straight line as the incident ray.
B. The incident ray bends away from the normal upon entering the glass.
C. The sine of the angle of incidence will equal the sine of the angle of refraction.
D. The emergent ray bends away from the normal.
E. The direction of the emergent ray has no relation to the direction of the incident ray.

126. Given an object located between a convex lens and its
(1.10) principal focus, the image seen from the opposite side of the lens is

A. real and inverted. **B.** virtual and erect.
C. real and virtual. **D.** virtual and inverted.

127. The bending or spreading of a light wave into the
(1.10) shadow when it passes the edge of an obstacle is called

A. refraction. **B.** diffraction. **C.** reflection.
D. abberation. **E.** astigmatism.

128. With a certain convex lens, a real image is formed 60
(1.10) cm. from the lens when the object distance is 12 cm.; likewise a real image is formed 12 cm. from the lens when the object distance is 60 cm. This is explained by the fact that

A. the lens is symmetrical in shape.
B. the lens has conjugated foci.
C. the lens has spherical aberration.
D. a convex lens may form a real or a virtual image.
E. the power of a lens equals 1/f.

For each item 129 - 136, blacken space

A. if the blank would best be filled by the word "reflection."
B. if the blank would best be filled by the word "refraction."
C. if the blank would best be filled by the word "diffraction."
D. if the blank would best be filled by the word "interference."
E. if the blank would best be filled by the phrase "the Doppler effect."

129. Microscopes make use of________in the lenses of their
(1.10) eyepieces and objectives.

130. When a ray of light strikes an optically smooth surface,
(1.30) that part of the ray which does not penetrate into the new medium behaves in such a way that the angle of incidence is equal to the angle of________.

131. The spectral lines of light from distant galaxies are
(1.10) slightly shifted toward the red. This has been interpreted as being due to________.

132. The spectral lines of the stars in the plane of the earth's
(2.10) orbit show an annual periodic shift in frequency toward the red at one time and toward the violet six months later. This is due to the revolution of the earth about the sun and is an example of________.

133. All lenses bend light by________.
(1.10)

134. One can see objects which do not themselves emit light
(1.10) only because of________of light.

135. A swimming pool ten feet in depth does not appear to
(1.10) be so deep when observed from above, because of ________.

136. The native Indian learned by experience that, if he was
(1.10) to spear a fish in water, it was necessary to aim below the apparent position of the fish because of________of the light rays.

137. The shimmering or wavy lines that can often be seen
(1.10) near the ground on a very hot day are the results of

A. heat waves. **B.** reflection of light waves.
C. refraction of light waves.
D. diffraction of light waves. **E.** an optical illusion.

The numbers preceding the paired items in the exercise below refer to the corresponding numbers on the answer sheet. Considering each pair from the standpoint of quantity, blacken space

A. if the item in Column I is greater than the item in Column II.
B. if the item in Column II is greater than the item in Column I.
C. if the two items are of essentially the same magnitude.

	Column I		*Column II*
138. (1.10)	Extent to which a ray of light is bent when it enters plate glass at an angle from the air.	....	Extent to which the ray of light is bent as it leaves the plate glass and again travels through the air.
139. (1.10)	Velocity of light in air.	....	Velocity of light in water.
140. (1.10)	Velocity of waves of ultra-violet light in a vacuum.	....	Velocity of cosmic rays in a vacuum.
141. (1.10)	Possibility that an incandescent solid, liquid or compressed gas will give a bright-line spectrum.	....	Possibility that an incandescent rarefied gas will give a bright-line spectrum.

142. When an object is viewed at a distance and then brought
(1.10) very close to the eye under the same light conditions, the part of the eye most subject to change is the

A. cornea. **B.** iris. **C.** pupil. **D.** lens.
E. retina.

143. The glow of animal eyes at night is explained prin-
(1.10) cipally by means of

A. fluorescence. **B.** phosphorescence.
C. reflection of light. **D.** refraction of light.
E. diffraction of light.

144. A simple astronomical telescope is made with two lenses
(1.10) of focal lengths 50 cm. and 5 cm., respectively. Which one of these statements is false?

A. The eyepiece is a diverging lens.
B. The magnifying power is 10.
C. The image is inverted.
D. The eyepiece forms an image in its focal plane.
E. The objective lens is convex.

145. The blue color of a blue eye is caused by
(1.10)

A. reflection of light from the blue pigment of the eye.
B. chromatic refraction by the lens of the eye and subsequent absorption of all colors except blue by the blue pigment of the eye.
C. the absorption of all incident light by the iris of the eye and subsequent emission of blue light by the iris.
D. scattering of light from a host of tiny, colorless particles in the eye.
E. none of the above.

146. When any one of the known elements is in the form of
(1.10) luminous gas, the type of spectrum obtained from it is known as

A. absorption. **B.** band. **C.** Fraunhofer.
D. continuous. **E.** bright line.

147. When a ray of light passes by a straight edge, it spreads
(1.10) somewhat in to the geometrical shadow; this is called

A. diffraction. **B.** refraction. **C.** dispersion.
D. scattering. **E.** interference.

148. The sunset red colors are due to the fact that
(1.10)

A. an optical illusion exists.
B. red light travels more slowly and is the last to arrive.
C. blue light is refracted to a different locality.
D. the shorter wave lengths of light are to a large extent absorbed or scattered.
E. blue light is reflected by the atmosphere.

149. The sun's spectrum is an example of
(1.10)

A. a mass spectrum. **B.** a continuous spectrum.
C. a bright line spectrum.
D. an absorption spectrum. **E.** a band spectrum.

150. Accommodation, or adjustment of the eye to see clearly
(1.10) objects at different distances, is brought about by

A. changing the image distance.
B. changing the size of the pupil.
C. changing the curvatures of the crystalline lens.
D. turning the eyes from side to side.

151. The index of refraction of a substance is practically
(1.10)

A. the speed of light in that substance.
B. the same as the angle of refraction.
C. the same as the angle of incidence.
D. the speed of light in air divided by its speed in that substance.
E. measured in cms.

152. If light is falling on a screen at the rate of one lumen
(1.10) per square foot
(2.10)

A. the screen must be one foot from the light source.
B. the illumination on the screen is one foot candle.

C. the light source must have an intensity of one candlepower.
D. the illumination on the screen is 4π foot candles.
E. the light source must have an efficiency of one candlepower per watt.

153. (1.10) The microscope is a lens combination which

A. gives a virtual image of the object.
B. gives a real image of the object.
C. consists entirely of divergent lenses.
D. has an objective of great focal length.
E. consists of a divergent and a convergent lens cemented together.

154. (1.10) An achromatic lens is designed particularly to

A. produce dispersion without deviation.
B. overcome spherical aberration.
C. produce a long focal length.
D. produce deviation without dispersion.
E. produce a continuous spectrum.

155. (1.10) When light waves are bent around a sharp edge into the shadow region, there is said to take place

A. refraction. **B.** diffraction. **C.** dispersion.
D. polarization. **E.** reflection.

156. (1.10) A "white dwarf" star consists of a very hot solid mass without an atmosphere. Its spectrum is

A. a bright line spectrum.
B. a continuous spectrum.
C. a continuous spectrum crossed by dark lines.

157. (1.10) A ray of light traveling toward a concave mirror crosses the principal axis at the center of curvature. After reflection it passes

A. through the vertex.
B. through the center of curvature.
C. through a point halfway between the focal point and the mirror.
D. through the focal point.
E. through none of the above points.

158. (1.10) A ray of light is traveling toward a converging lens. It crosses the principal axis at the optical center. After passing through the lens it would go on

A. through the focal point behind the lens.
B. as if from the focal point in front of the lens.
C. undeviated.
D. through the center of curvature of the front surface.
E. through the center of curvature of the rear surface.

159. (1.10) Two beams of light, one blue and one yellow, are thrown upon the same spot of a white screen. The combined color is

A. white. **B.** yellow. **C.** black. **D.** blue.
E. violet.

160. (1.10) The color of a piece of red glass is due to

A. a chemical action of the light on the glass.
B. the absence of red in the light by which it is viewed.
C. the fact that red light is always more readily reflected than other colors.
D. the fact that red is refracted less than other colors.
E. absorption of other colors by the glass.

161. (1.10) If a ray of light changes its direction when passing from one substance to another we say it is

A. reflected. **B.** diffracted. **C.** dispersed.
D. refracted. **E.** diffused.

162. (1.10) When a wave front meets a reflecting surface the direction taken by the reflected wave is determined by the

A. material of the reflecting surface.
B. angle of incidence. **C.** nature of the medium.
D. intensity of the disturbance.
E. wave length of the light.

163. (1.10) Intereference phenomena in light indicate that

A. light waves are capable of being polarized.
B. light waves are transverse.
C. light is electromagnetic in character.
D. light is some sort of wave disturbance.

164. (1.10) A star with a white hot liquid surface enveloped in a glowing gaseous atmosphere gives

A. a spectrum of bright lines.
B. a continuous spectrum.
C. a continuous spectrum crossed by brighter lines.
D. a continuous spectrum crossed by dark lines.

165. (1.10) If the lines in the spectrum of a star are displaced from their normal position toward the blue the earth and the star are

A. approaching each other.
B. receding from each other.

166. (1.10) Which, if any, of the following statements (A-D) would Young regard as *incorrect?*

A. Two beams of light from the same source may combine so as to produce at a certain point, less illumination than either alone.
B. Two beams of light from the same source may combine so as to produce, at a certain point, more illumination than the sum of what each alone would produce.
C. If one beam of light crosses another, it is always propagated beyond the region of crossing just as it would have been had no second beam been present.
D. Two beams of light falling upon an object may produce a uniform illumination just equal to the sum of what each alone would produce.
E. Young would regard each of the above statements as correct.

Imagine a particle to be vibrating, not irregularly (as Huygens supposes the particles of matter to vibrate), but with a constant frequency; and suppose it thereby to collide periodically with a hard, spherical body in contact with a system of such bodies, the system as a whole thus being similar to Huygens' "ether."

Each of the following items (167 - 176) consists of a statement about the role in the above situation of a certain factor "X." For each item, blacken answer space

A. if the statement becomes a true one if "X" refers to the frequency of the vibrating particle.
B. if the statement becomes a true one if "X" refers to the elasticity of the ether particle.
C. if the statement becomes a true one if "X" refers to the vigor of the particle vibration, as measured by the size of the "dent" it makes in the ether particle it strikes.

D. if the statement becomes a true one if "X" refers to the size of the vibrating particle.
E. if the statement is not made true by any of the above interpretations of "X."

167. (1.10) X influences the frequency of the resulting wave disturbance.

168. (1.10) X completely determines the frequency of the resulting wave disturbance.

169. (1.10) X completely determines the frequency of the resulting wave disturbance, and influences the intensity (energy) of that disturbance.

170. (1.10) X influences the speed of propagation of the wave disturbance.

171. (1.10) X completely determines the speed of propagation of the wave disturbance.

172. (1.10) X completely determines the speed of propagation of the wave disturbance, and influences the spacing of the successive wave crests.

173. (1.10) X completely determines the intensity (energy) of the wave disturbance.

174. (1.10) X has no effect upon any characteristic of the wave disturbance.

175. (1.10) X has no effect upon the speed of propagation of the wave disturbance, but does affect the spacing of the successive wave crests.

176. (1.10) X completely determines the spacing of the successive wave crests.

177. (1.22a) In the lens formula, p and q are interchangeable. This illustrates

A. a defect in the lens. **B.** Snell's Law.
C. conjugate foci.
D. that the angle i = the angle r.
E. that the image may be real or virtual.

178. (1.22a) In a laboratory experiment demonstrating the principle of conjugate foci, a student using a converging lens of 10 cm. focal length produces an image 12 cm. from the lens when the object distance is 60 cm. When he repeats the experiment with the object distance as 12 cm., the new image distance would

A. have to be re-calculated using the lens formula.
B. be exactly 10 cm. **C.** still be 12 cm.
D. be 60 cm.
E. be negative showing that a virtual image would be formed.

179. (1.22a) The focal length of a lens can be most conveniently estimated by a student in the laboratory (with fair accuracy) by

A. comparing with a lens of known focal length.
B. applying the formula $\frac{1}{p} + \frac{1}{q} = \frac{1}{f}$.
C. observing the comparative convexity or concavity of the lens and from this estimating the radius of the circle of which the lens is a part.
D. observing the distance from the lens to the image formed by a distant object.
E. applying the formula $f = \frac{Y^2 - D^2}{4Y}$.

180. (1.22a) If the focal length of a positive lens were 10 cm., in order to form a virtual image the object distance could be

A. 5 cm. **B.** 10 cm. **C.** 20 cm. **D.** infinity.
E. none of these.

181. (1.20) All of the following concerning a virtual image formed by any single lens are correct *except*

A. it is always erect.
B. it is always on the same side of the lens as the object.
C. it is always smaller than the object.
D. it is always formed so that the light seems to come from the image.
E. all of the above are correct.

182. (1.24) One advantage of a reflecting telescope over a refracting telescope for photographic purposes is that it

A. requires a much shorter exposure time to obtain an image on a photographic plate.
B. brings to focus on one and the same focal plane colors of all wave lengths.
C. does not need a driving clock to continually point the telescope at the moving celestial sphere.
D. does not require the clear atmospheric conditions necessary before the photographic refractor can be used.
E. None of these.

183. (1.24) A quick check to tell that a lens is diverging rather than converging can be made by

A. measuring its focal length.
B. measuring its diameter.
C. focusing its image on a screen.
D. measuring the thickness of its edges.
E. looking through it at some object.

Item 184 deleted.

185. (1.24) A beam of light passes through a small hole in a screen, and illuminates a circular area on a second screen. Some of the light passes through two holes within the illuminated area on the second screen to form two illuminated but overlapping circular areas on a third screen. Where the two areas overlap alternate bright and dark lines appear. This experiment supports the theory that light

A. can be reflected. **B.** is a form of wave motion.
C. consists of photons.
D. does not travel through a vacuum.

186. (1.24) Which of the following facts supports a modern corpuscular, or particle, theory of light rather than the wave theory?

A. Light travels three-fourths as fast in water as in air.
B. Light is diffracted on passing through a small opening.
C. The velocity of travel of electromagnetic waves is the same as the velocity of light.
D. Light immediately causes ejection of electrons in a photoelectric tube.
E. Light exhibits interference and reinforcement effects.

187. (1.24) Light has wave characteristics. Which of the following is the best experimental evidence for this statement?

A. Light can be reflected by a mirror.
B. Light forms dark and light bands on passing through two slits close together.
C. A beam of white light can be broken into its component colors by a prism.
D. Light operates a photoelectric cell.
E. Light carries energy.

188. (1.25) The spectroscope

A. is most useful to the chemist in studying the light emitted by incandescent solids.
B. is used for the analysis of X-rays.
C. is only useful for the analysis of molecules.
D. makes use of the Tyndall effect.
E. causes light of different wave-lengths to follow different paths through a prism.

189. (1.10) A man sees a distant star as a short, straight line. The defect of his eyes is

A. spherical aberration. **B.** chromatic aberration.
C. astigmatism. **D.** near-sightedness.
E. far-sightedness.

190. (1.25) The man of the previous problem could correct his vision by use of

A. a cylindrical lens. **B.** a converging lens.
C. a diverging lens. **D.** a polaroid lens.
E. dark glasses.

191. (1.30) Which of the following is the best statement of the principle underlying the operation of a spectroscope?

A. A prism permits separation of a mixture of varying length light waves.
B. The color of light emitted by an incandescent object is determined by the composition of the object.
C. Simultaneously produced images of a narrow slit can be separated by the action of a prism and lenses.
D. Incandescent solids give continuous spectra and incandescent gases show bright line spectra.
E. Fraunhofer lines separate different components of light with infinite accuracy.

192. (1.30) By placing the object at various distances, a convex lens may form all of these *except*

A. an image in color. **B.** a diminished virtual image.
C. an enlarged erect image.
D. a magnified real image.
E. a diminished inverted image.

Items 193 - 197 refer to the characteristics of images formed by various lenses. These characteristics are

a. Upright image. b. Inverted image.
c. Virtual image. d. Real image.
e. No definable image formed.

For items 193 - 197 select from the key the most appropriate response.

KEY

A. a and c. **B.** a and d. **C.** b and d.
D. b and c. **E.** e.

193. (1.30) Which one lists all and only the characteristics of the image formed by a convex lens being used as a simple eyepiece on a laboratory microscope in good adjustment?

194. (1.30) Which one lists all and only the characteristics of the image when an object is placed at the focal length of a convex (positive) lens?

195. (1.30) Which one lists all and only the characteristics of the image which is formed on the retina of the eye having normal vision?

196. (1.30) Which one lists all and only the characteristics of the image formed when an object is placed at a greater distance from a concave (negative) lens than the focal length?

197. (1.30) Which one lists all and only the characteristics of the image formed when an object is placed at a distance less than the focal length from a lens which is thicker in the middle than at the edges?

Items 198 and 199 refer to the characteristics of images formed by convex lenses under certain conditions. These characteristics are

a. Upright image. b. Inverted image.
c. Virtual image. d. Real image.

198. (1.30) Which one of the following lists all, and only the characteristics when a lens is used as a simple magnifying glass?

A. a and c. **B.** a, c, and d. **C.** b and d.
D. a and d. **E.** b and c.

199. (1.30) Which one lists all, and only the characteristics of the image formed on a film in a camera?

A. a and c. **B.** a, c, and d. **C.** b and d.
D. a and d. **E.** b and c.

200. (1.30) The eyes of a person shifting his vision between the frame of a mirror and the image of a distant object in the mirror,

A. do not have to accommodate (refocus) to see the object because the mirror is the same distance from eye as the wooden frame.
B. do not have to accommodate because the image is virtual.
C. have to accommodate because the image appears behind the mirror, not at the surface of the mirror.
D. do not have to accommodate because the image is real.
E. have to accommodate because the image appears smaller than the object from where he stands.

201. (1.30) The principle underlying the operation of a photoelectric cell:

A. Radiation may cause some substances to emit electrons.
B. Electrons may be emitted from certain substances at high temperatures.
C. A changing magnetic or electro-magnetic field may produce a flow of electrons.
D. Radiation may be re-radiated at different wave lengths.
E. Electrons may cause radiations to be emitted from some substances.

202. A beam of white light
(1.30)

A. is diffracted and refracted if it enters a glass object exactly at right angles to the surface.
B. has the same velocity in water and glass as it has in air.
C. in passing from a less to a more dense medium is bent toward the normal to the surface separating the two media.
D. is accepted as being composed of particles, since this offers the best explanation of interference phenomena.
E. is reflected from a plane mirror at an angle equal to the angle of refraction.

203. A single lens does not focus all colors from a distant source of white light at the same point. Thus red is converged to a point farther from the lens than is blue. Which of the following is most directly useful in explaining this?
(1.30)

A. The resolving power of a lens depends upon the wave length of light used.
B. The speed of light in glass depends upon the composition of the glass.
C. The angle of refraction depends upon the wave length of light used.
D. The fraction of light transmitted by a medium depends upon the nature of the medium.
E. The angle of refraction depends upon the angle of incidence.

204. A converging lens of 10 cm. focal length forms an image 12 cm. from the lens when the object distance is 60 cm. If the experiment is repeated with the object distance as 12 cm., the new image distance would
(1.30)

A. have to be re-calculated. **B.** be 10 cm.
C. cause the image to be smaller than before.
D. be 60 cm.
E. be negative indicating a virtual image.

205. If an erect lamp is placed 18 cm. from a converging lens of focal length 12 cm., the only image which can be formed is one which is
(1.30)

A. virtual, erect, magnified.
B. real, erect, magnified.
C. virtual, inverted, magnified.
D. real, inverted, magnified.
E. real, erect, smaller.

206. The assumption that light waves are transverse is necessary in order to explain
(1.30)

A. reflection. **B.** refraction. **C.** polarization.
D. diffraction. **E.** Huyghen's principle.

207. In the electromagnetic spectrum
(1.30)

A. ultra-violet has longer wave lengths than the infra-red.
B. blue light is of higher frequency than X-rays.
C. radio waves have shorter wave lengths than gamma rays.
D. gamma rays have higher frequency than infra-red.
E. cosmic rays are low-frequency radio waves.

208. A beam of light traveling parallel to the principal axis strikes a concave mirror. After reflection it passes
(1.30)

A. back on *itself*.
B. through the center of curvature.
C. through a point halfway between the focal point and the mirror.
D. through a point halfway between the center of curvature and the mirror.
E. none of the above answers.

209. If a star is moving away from the earth, the lines of its spectrum are displaced toward the red end. This phenomenon is an illustration of
(1.30)

A. Doppler's principle. **B.** Huyghen's principle.
C. the Young-Helmholtz theory.
D. Wien's displacement law.
E. the red-shift due to increased pressure.

210. The formation of a spectrum by a grating is due to the fact that
(1.30)

A. various colors have different speeds.
B. the amount of refraction varies with the wavelength of light.
C. polarization takes place.
D. the lines on the grating screen cut the various colors in certain directions.
E. interference between diffracted waves occurs.

211. A deep blue colored automobile under the yellow sodium light of a modern highway will appear
(1.30)

A. black. **B.** white. **C.** yellow. **D.** green.
E. blue.

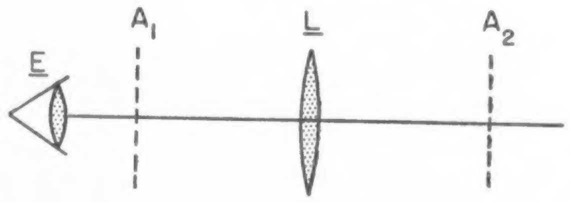
212. In the spectrum of white light formed by a diffraction grating
(1.30)

A. the blue lies nearer the central image than the red.
B. the red lies nearer the central image than the blue.
C. the spectral colors are not the same as in the prism spectrum.
D. the spectrum appears on only one side of the central image.

213. In using a converging lens of 10 inches focal length, as a distant object moves toward the lens (say from 2000 ft. to 1000 ft.) its image
(1.30)

A. does not move appreciably.
B. moves to the left.
C. also moves toward the lens.
D. moves at least half-an-inch farther from the lens.

214. E is an eye, L is a lens with focal planes A_1 and A_2.



(1.30) To use this lens as a magnifier the object should be placed

A. at A_2. **B.** just beyond A_2.
C. just inside A_2.
D. twice the distance of A_2 from the lens.
E. half way between the lens and A_2.

215. (1.30) Which of the following descriptions could not possibly apply to a spectrum?

- **A.** A rectangle, with its longer side horizontal, containing vertical bands of color gradually shading into one another from left to right, but with the orange band on one side and the green on the other gradually fading into an intermediate dark region, crossed at its center by a single thin vertical line of yellow.
- **B.** A rectangle, with its longer side horizontal, containing a series of distinct, sharp, narrow vertical lines of different colors separated by dark regions.
- **C.** A rectangle, with its longer side horizontal, containing horizontal bands of color shading gradually from red at the bottom to violet at the top.
- **D.** Each of the above descriptions is possible.
- **E.** None of the above descriptions is possible.

216. (2.00) Fraunhofer's spectroscope used a narrow slit through which the light passed, a prism to produce a spectrum and a system of lenses. The role of the slit was

- **A.** to increase the ratio of the length of the spectrum (i.e., the distance from the extreme red to the extreme violet) to its width.
- **B.** to increase the index of refraction of the prism.
- **C.** to diminish the distance between different colors.
- **D.** to diminish the overlapping of different colors.
- **E.** to adapt the beam more adequately to the "line" structure of the spectrum.

217. (2.00) The chief role of the lens was

- **A.** to produce an image of the slit.
- **B.** to produce a real image of the sun.
- **C.** to produce a virtual image of the sun.
- **D.** to make the spectrum larger, and thus render visible finer detail.
- **E.** to make it possible to produce a sharp spectrum even with a wide opening.

218. (2.00) Which, if any, of the following phenomena puts a serious theoretical difficulty in the way of attempting to characterize the behavior of light in terms of Newtonian "rays"?

- **A.** The separation of the components of composite light by a prism, which would force one to assert that there are at a given point in a beam of light an infinite number of rays.
- **B.** the spreading out of a beam of light in passing through a small hole, which destroys the possibility of subdividing such a beam indefinitely into ever narrower parts.
- **C.** The speed at which light travels, which is so enormously great as to be an insuperable obstacle to any attempt to separate a "chunk" of light disconnected from its source.
- **D.** The fact that the light always travels with the same speed in a vacuum, which means that no physical agency can alter the speed of a ray unless it passes into a refracting medium.
- **E.** None of the above; for all the phenomena listed can be characterized in terms of the behavior of rays.

219. (2.00) According to Newton the proposition that the light at a certain point at various times represents different "rays" depends upon

- **A.** the assumption that the speed of light is finite.
- **B.** the assumption that light is propagated in straight lines from its source.
- **C.** the assumption that light is propagated in all directions from its source.
- **D.** the assumption that light is emitted intermittently from its source in any given direction.
- **E.** none of the above assumptions.

True or False.

220. (2.10) The intensity of light four feet from a sixteen candle power lamp is sixteen foot candles.

221. (2.10) If an object is placed 18 cm. from a converging lens of 6 cm. focal length, the distance from the lens to the image is

$$\text{Given: } \frac{1}{p} + \frac{1}{q} = \frac{1}{f}$$

A. 12 cm. **B.** 4.5 cm. **C.** 72 cm.
D. 24 cm. **E.** none of these.

Items 222 - 223 refer to the lenses for the equation:

$$\frac{1}{p} + \frac{1}{q} = \frac{1}{f}$$

222. (2.10) When the object distance of a convex lens is 200 ft. and the focal length 1 ft., the image distance is approximately

A. ½ ft. **B.** 1 ft. **C.** 199 ft. **D.** 9/10 ft.
E. a number quite different from any of the above.

223. (2.10) If a convex lens (positive lens of 10 cm. focal length) were used in such a way as to produce a virtual image, the object distance could be

A. 5 cm. **B.** 15 cm. **C.** 20 cm.
D. any value greater than 20 cm.
E. none of the above range of values.

224. (2.10) If a real image four times the size of the object is formed by a converging lens of focal length 20 cm., the image distance is

Suggestions: Magnification is the ratio of image distance to object distance.

$$\frac{1}{p} + \frac{1}{q} = \frac{1}{f}$$

A. 4 cm. **B.** 25 cm. **C.** 60 cm. **D.** 100 cm.
E. none of these.

Items 225 - 229 refer to the use of lens formula,

$$\frac{1}{p} + \frac{1}{q} = \frac{1}{f}$$

225. (2.10) When an object is placed 20 cm. in front of a diverging lens with a focal length of −10 cm., the image distance (in cm.) is

A. −6.67 **B.** 20.0 **C.** 10.0 **D.** −10.0
E. none of these.

226. (2.10) When an object is placed 4 cm. in front of a converging lens with a focal length of 5 cm., the image distance is

A. 1 cm. **B.** −5 cm. **C.** 20 cm.
D. −20 cm. **E.** 2.2 cm.

227. When an object is 8 inches from a convergent lens, its **(2.10)** real inverted image is 24 inches on the other side of the lens. The focal length of the lens is

A. 24 in. **B.** 12 in. **C.** 6 in. **D.** 2 in.
E. 8½ in.

228. When an object is placed 30 in. in front of a convex **(2.10)** lens of focal length 5 in., the image distance is

A. 4.3 in. **B.** 25 in. **C.** −4.3 in.
D. 1/6 in. **E.** none of these.

229. When an object is placed 8 cm. in front of a converging **(2.10)** lens and a virtual image is formed 40 cm. from the lens, the focal length is

A. 10 cm. **B.** −6.7 cm. **C.** 1/10 cm.
D. 6.7 cm. **E.** none of these.

230. With a certain convex lens, a real image is formed **(2.10)** 60 cm. from the lens when the object distance is 12 cm. likewise a real image is formed 12 cm. from the lens when the object distance is 60 cm. This is explained by the fact that

A. the lens is symmetrical in shape.
B. the lens has conjugated foci.
C. the lens has spherical aberration.
D. a convex lens may form a real or a virtual image.
E. a convex lens has two focal lengths.

231. A diverging (concave) lens forms an image 10 cm. from **(2.10)** the lens when the object is placed 20 cm. from the lens.

The lens formula is: $\frac{1}{p} + \frac{1}{q} = \frac{1}{f}$.

The focal length of the lens is

A. 10 cm. **B.** −10 cm. **C.** 6.7 cm.
D. −6.7 cm. **E.** none of these.

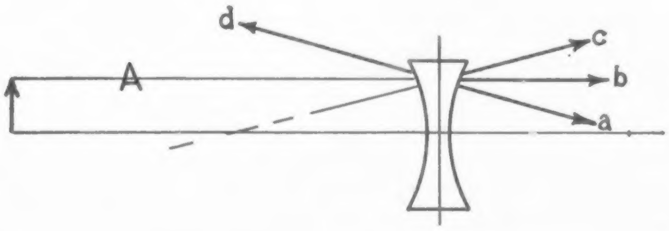
232. The lens formula is $\frac{1}{p} + \frac{1}{q} = \frac{1}{f}$. If the distance is **(2.10)** 100 meters and the image distance is 10 cm., the focal length of the lens is

A. 91. cm. **B.** .11 cm. **C.** 10 cm.
D. 110 cm. **E.** none of these.

233. Chromatic aberration in a single lens is *best* explained **(2.10)** by the statement

A. The angle of refraction depends upon the wave length.
B. The refractive power varies greatly with the kind of glass used.
C. Light travels more slowly through glass than air.
D. A lens absorbs some colors better than others.
E. The angle of incidence affects the angle of refraction.

Item 234 refers to this diagram.



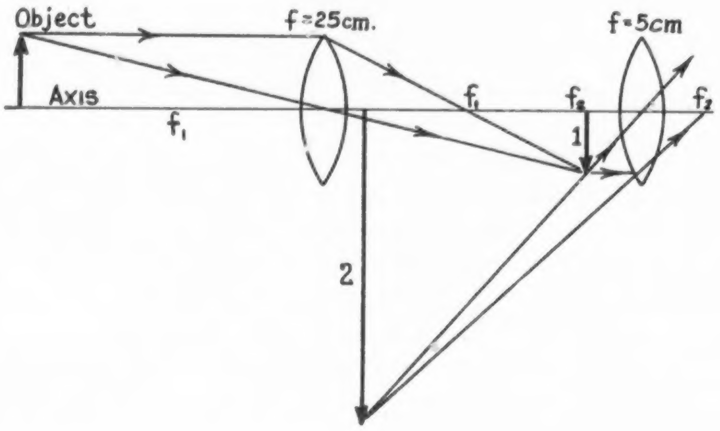
234. Ray of light A will, after striking the lens, follow path **(2.10)**

A. a. **B.** b. **C.** c. **D.** d. **E.** none of these.

235. An ice cube ground up appears almost white rather **(2.10)** than colorless as in the transparent state. This is caused by

A. the scattering of light. **B.** chemical changes.
C. refraction of light. **D.** the dispersion of light.
E. the interference of light.

Items 236 - 237 refer to the following diagram of an optical instrument.

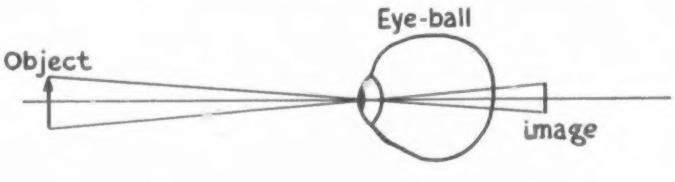


236. Which one of these statements is true? **(2.10)**

A. The diagram is correct for an astronomical telescope.
B. The diagram is correct for a microscope.
C. The diagram is correct for a terrestrial telescope.
D. The diagram is correct for an opera glass.
E. The diagram is incorrect for any of the above.

237. Which one of these statements is false? **(2.10)**

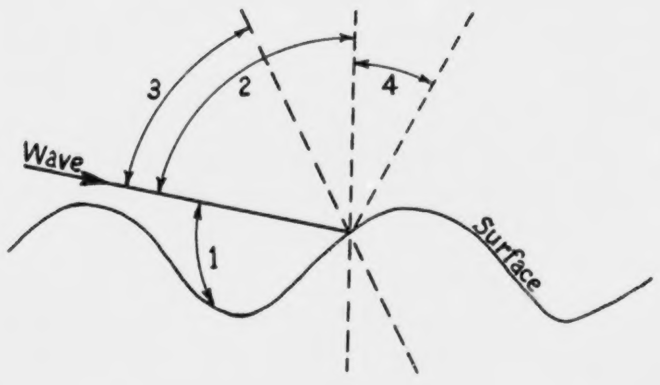
A. Image 2 is virtual. **B.** Image 1 is real.
C. The magnifying power is 5.
D. Image 2 can be focused on a screen at that point.
E. None of the above.



238. If the distance for a distinct image formed by the lens **(2.10)** system of the eye were as shown above, the person would certainly have

A. astigmatism. **B.** spherical aberration.
C. near-sightedness. **D.** far-sightedness.
E. an erect image on the retina of the eye.

239. In the following diagram, the angle of incidence of a **(2.10)** wave striking a curved reflecting surface is numbered



A. 1. **B.** 2. **C.** 3. **D.** 4. **E.** 5.

240. (2.10) Of the following, the lens that would be most suitable for the objective of a simple telescope would be

A. a lens 3 in. in diameter, slightly thicker in the middle than the edges, and forming a reduced inverted image of a distant object.

B. a lens 1½ in. in diameter, much thicker in the middle than the edges.

C. a lens 1 in. in diameter, with relatively thick edges and very thin through the middle, and always forming an erect image.

D. a pair of lenses cemented together, one convex and one concave, but with greater total thickness through the middle than the edges.

241. (2.10) Astigmatism may be explained as

A. the lack of sharp focus of rays parallel to the axis of the eye, which enter near the edge of the lens.

B. due to the greater convexity of the lens of the eye in one plane than another.

C. the dispersive effect of the lens of the eye.

D. chromatic aberration.

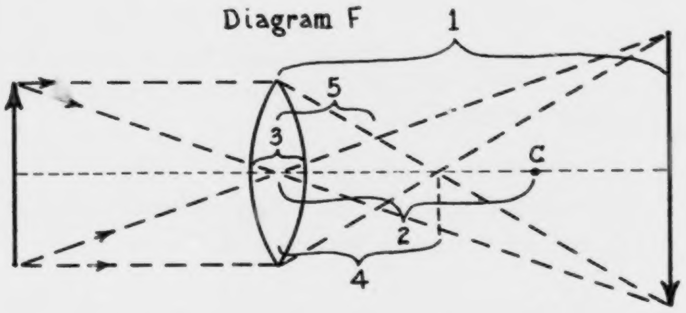
E. the formation of an image before it reaches the retina of the eye.

242. (2.10) The mean distance from the earth to the sun is about 93,000,000 miles. The time required for the light traveling at 186,000 miles per second to reach the earth from the sun is

A. 500 minutes. **B.** 2 seconds. **C.** 118 seconds. **D.** 18 minutes. **E.** less than a second.

243. (2.10) The focal length of the lens in Diagram F is indicated by number

Diagram F



A. 1. **B.** 2. **C.** 3. **D.** 4. **E.** 5.

Items 244 - 249.

The white light which we receive from the sun is really a mixture of all the colors. This was first demonstrated by Newton, who was one of the great pioneers in the study of light. Newton allowed a narrow beam of sunlight to pass into a triangular glass prism. He noticed that the beam diverged after leaving the prism and emerged in a rainbow-like band of colors. The red part was refracted the least by the prism and the violet the most. Newton concluded that these are the colors of which sunlight is composed, and he tested this conclusion by passing the colors into a second inverted prism and obtained white light as a result.

Blacken space

A. if the item is true and its truth is supported by the paragraph.

B. if the item is true but its truth is not supported by the paragraph.

C. if the item is false and it is shown to be false by the paragraph.

D. if the item is false, but its falsity is not shown by the paragraph.

244. (2.10) White light is composed of all of the various colors of light.

245. (2.10) White light can be obtained by passing red light through an inverted prism.

246. (2.10) Raindrops may act somewhat like prisms.

247. (2.10) Newton used the scientific method in his study.

248. (2.10) This rainbow-like band of colors is called a continuous spectrum.

249. Sunlight is the only source of light which will produce such a band of color.

250. (2.10) Index of refraction of light is equal to the ratio of

A. the frequency and the wave length.

B. the velocity in air and in another medium.

C. the velocity and the frequency.

D. the sine of the angle of incidence and the sine of the angle of reflection.

E. the angle of incidence and the angle of refraction.

251. (2.10) When the atmosphere is not quite clear, one may sometimes see colored circles concentric with the sun or moon, generally not more than four or five times the diameter of the sun or moon and invariably having the inner edge blue. The explanation of this phenomenon involves the

A. reflection of light. **B.** refraction of light.
C. interference of light. **C.** diffraction of light.
E. Doppler effect.

252 - 257 involve the images formed by a converging lens of focal length 10 cm. Select from the key the condition necessary to produce the effect stated by each item.

KEY

A. Object placed at the focal point in front of the lens.

B. Object placed 12 cm. from the lens.

C. Object placed 8 cm. from the lens.

D. Object placed 100 cm. from the lens.

E. None of these.

252. (2.10) Real, inverted image, larger than the object.

253. (2.10) Image rays are parallel.

254. (2.10) Virtual image, smaller than the object.

255. (2.10) Virtual image, larger than the object.

256. (2.10) Real erect image, larger than the object.

257. (2.10) The magnifying power of a telescope

A. depends upon the diameter of the lenses used.

B. depends entirely upon the focal length of the eyepiece.

C. is changed if a concave lens of equal focal length is used in place of a converging eyepiece.

D. is a ratio of the focal length of the objective to that of the eyepiece.

E. depends upon the magnitude of the object distance.

Item 258 deleted.

259. (2.1) A convex spherical mirror has a radius of curvature equal to 24 cm. If an object is placed 24 cm. in front of the mirror, the distance of its image from the mirror is

A. 2 cm. **B.** 8 cm. **C.** 24 cm. **D.** 36 cm. **E.** infinite.

260. (2.10) The image observed in a plane mirror is a virtual image. This means that

A. it is actually on the surface of the mirror.

B. it cannot be photographed by a camera.

C. it is in front of the mirror.

D. it has none of the properties of a real image.

E. it cannot be caught on a screen.

261. (2.10) The speed of light in glass of refractive index 1.5 is

A. 220 meters/sec. **B.** 331 meters/sec.

C. 200 million meters/sec.

D. 300 million meters/sec.

E. 450 million meters/sec.

262. (2.10) A man holds his book 10 cms. from his eyes to read without spectacles. He has

A. chromatic aberration. **B.** spherical aberration.

C. near-sightedness. **D.** far-sightedness.

E. astigmatism.

263. (2.10) When the face is placed one foot in front of a shaving mirror, an image twice the size of the face is produced. The mirror is

A. convex with a focal length of 24 in.

B. concave with a focal length of 24 in.

C. convex with a focal length of 8 in.

D. concave with a focal length of 8 in.

E. convex with a focal length of 12 in.

264. (2.10) Two thin lenses of the same size and shape are made of optical glasses of refractive indices 1.5 and 1.8, respectively. The ratio of their focal length is

A. 1.0 **B.** 1.2 **C.** 1.4 **D.** 1.6 **E.** 1.8

265. (2.10) An object is 2 ft. in front of a plane mirror. The image is

A. virtual, inverted, and 2 ft. behind the mirror.

B. virtual, inverted, and 2 ft. in front of the mirror.

C. virtual, erect, and 2 ft. in front of the mirror.

D. real, erect and 2 ft. behind the mirror.

E. none of the above answers.

266. (2.10) In a photometer the candle power of the standard lamp is 20. When the screen is equally illuminated on both sides it is 2 ft. from the standard lamp and 3 ft. from the unknown lamp. The candle power of the unknown lamp is

A. 13.3 **B.** 15. **C.** 27. **D.** 30. **E.** 45.

267. (2.10) In Michelson's experiment, light travelled from Mount Wilson to Mount San Antonio and back (total distance 46 miles). The time required was approximately

A. 15.3×10^{-10} sec. **B.** 5.4×10^{-6} sec.

C. 2.5×10^{-4} sec. **D.** 1 sec. **E.** 17 min.

268. (2.10) Initially an incident beam of light is normal to the surface of the plane mirror in a galvanometer. When the mirror is rotated the incident and reflected beams make an angle of 30° with one another. The mirror has been rotated through an angle of

A. 0°. **B.** 15°. **C.** 30°. **D.** 45°. **E.** 60°.

269. (2.10) A slide two inches square is used in a lantern which has a projection lens having a focal length of 8 in. If the screen is nearly filled by the image when placed 16 ft. from the lantern, it should have a width of approximately

A. 3.5 ft. **B.** 4 ft. **C.** 4.5 ft. **D.** 5 ft.

E. 5.5 ft.

270. (1.10) When total reflection occurs at a surface the incident angle

A. must be in the medium of slow speed.

B. must be in the medium of high speed.

C. may be in either medium. **D.** is zero.

E. is always a very small angle.

271. (2.10) A converging lens of focal 6 inches is inserted in the path of a beam of converging rays of light. If the lens is one foot from the point of convergence of the incident beam, the image is:

A. non-existent. **B.** 4 inches in front of the lens.
C. 4 inches behind the lens.
D. 12 inches in front of the lens.
E. 12 inches behind the lens.

272. (1.10) A "white dwarf" star consists of a very hot solid mass without an atmosphere. Its spectrum is

A. a bright line spectrum.
B. a continuous spectrum.
C. a continuous spectrum crossed by dark lines.

273. (2.10) The image ordinarily observed in a plane mirror is a virtual image. This means that

A. it cannot be photographed by a camera.
B. is actually on the surface of the mirror.
C. it is completely a subjective effect.
D. it has none of the properties of a real image.
E. a camera film at the position where the image appears would not record the image.

274. (2.10) The index of refraction of water is 4/3. If one is looking vertically downward into the pool of water and a fish in the pool appears to be 12 ft. below the surface, the actual depth of the fish is

A. 6 ft. **B.** 9 ft. **C.** 12 ft. **D.** 16 ft.
E. 21 ft.

275. (2.10) The temperature of an arc lamp is 2900° absolute. The wave length at which the radiation has maximum energy is

A. 84×11^5 A. **B.** 1 A. **C.** 10^7 A.
D. 10,000 A. **E.** 10 A.

276. (2.10) A far sighted person can see an object distinctly at a distance of 1 meter. In order to see an object distinctly at a distance of 20 cm. he would have to be provided with glasses of

A. +4 diopters. **B.** −4 diopters.
C. +6 diopters. **D.** −6 diopters.
E. +10 diopters.

277. (2.10) Interference fringes are produced in an interferometer with light of 5×10^{-5} cm. wavelength. If one of the interferometer mirrors is moved back until 400 fringes have moved across the field of view, the distance the mirror has moved in cm. is

A. 10^{-4}. **B.** 2×10^{-4}. **C.** 10^{-3}.
D. 2×10^{-3}. **E.** 10^{-2}.

278. (2.10) A convex spherical mirror has a radius of curvature equal to 24 cms. If an object is placed 24 cms. in front of the mirror, the distance of this image from the mirror is

A. 2 cms. **B.** 8 cms. **C.** 24 cms.
D. 36 cms **E.** infinite.

279. (2.10) An object stands in front of a diverging lens. A proper graphical construction to locate the image is shown in figure________.

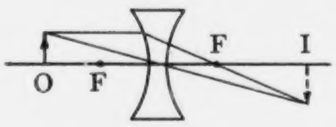


Fig. 1

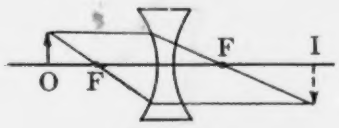


Fig. 2

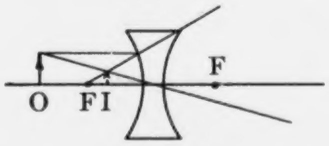


Fig. 3

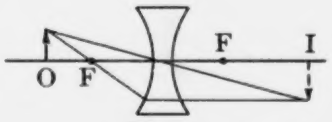


Fig. 4

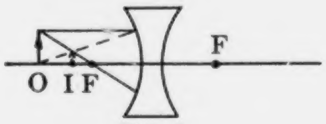


Fig. 5

280. (2.10) An object stands in front of a convex mirror. A graphical construction for locating the image is given in figure ________.

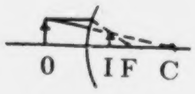


Fig. 1

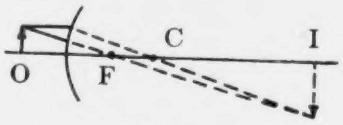


Fig. 2

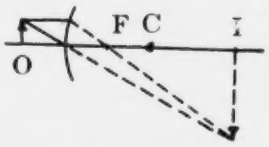


Fig. 3

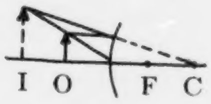


Fig. 4

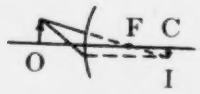
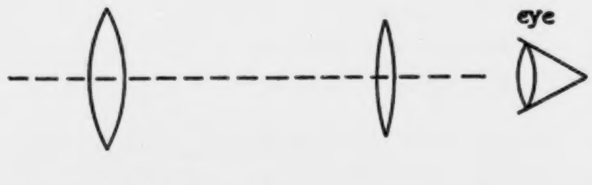


Fig. 5

281. (2.10) At a distance of 10 ft. from a standard 16 candle-power lamp the illumination is

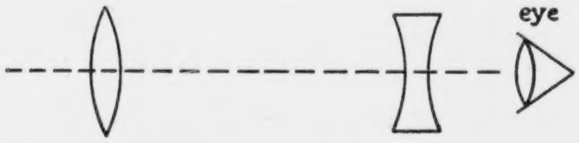
A. 160 foot-candles. **B.** 25.6 foot-candles.
C. 16 foot-candles. **D.** 1.6 foot-candles.
E. 0.16 foot-candles.

282. (2.10) The optical instrument shown in the diagram is



A. a simple magnifier.
B. an astronomical telescope.
C. a terrestrial telescope. **D.** an opera glass.
E. a compound microscope.

283. (2.10) The optical instrument shown in the diagram is



- **A.** a simple magnifier.
- **B.** an astronomical telescope.
- **C.** a terrestrial telescope. **D.** an opera glass.
- **E.** microscope.

284. (2.20) When sunlight streams through a small hole in a window shade, the visible beam reveals dust in the air. Which one of the following is most useful in explaining this?

- **A.** The radiant energy of the sun, changed into heat, sets the dust molecules into violent agitation.
- **B.** The light passing through the dust particles is refracted similar to refraction by glass.
- **C.** The phenomenon is known as the Brownian Movement.
- **D.** The dust particles scatter the light so that the dust becomes visible to the eye.
- **E.** The dust particles absorb radiant energy and become luminous.

Items 285 and 286 refer to a boy with a gun who is shooting fish from the bank of a clear stream.

285. (2.20) In order to hit the fish he should aim

- **A.** directly at the fish. **B.** below the fish.
- **C.** above the fish.

286. (2.20) Because

- **A.** in order to protect themselves fish have the ability to appear where they are not.
- **B.** light refracted from a denser to a rarer medium is always bent toward the normal.
- **C.** the fish appears to be deeper than it really is from the effect of the index of refraction of water compared to the index for air.
- **D.** light rays coming from the fish are bent away from the vertical at the surface.
- **E.** light travels in straight lines and the bullet travels so fast that little refraction can occur.

Items 287 - 293 are to be answered by reference to the following article adapted from *Science News Letter*, June 30, 1951, p. 403.

The universe continues to expand with extraordinary speed as far as the giant Hale telescope of Mt. Palomar has been able to detect the puzzling "red shift" in light from faint nebulae or universes.

On the spectrographic plates, light dispersed by a prism is broken down into its component wave lengths in a spectrum only a tenth of an inch long. Lines in that spectrum indicate the presence of particular wave lengths. With the distant object, these lines are shifted about one-twentieth of an inch toward the red, or longer wave length end of the spectrum.

A possibility exists that the light from far off objects may have lost energy during its long, lonely journey through space, causing its wave length to increase. In this case some principle of nature as yet unknown would account for the red-shifts.

287. (2.10) The statement "light dispersed by a prism" means that

- **A.** faint light from the stars is made visible.
- **B.** a permanent photographic record of the light is obtained.
- **C.** light is separated into different colors.
- **D.** only light of a certain wavelength passes through the given prism.
- **E.** the light is scattered in all directions.

288. (2.10) The "puzzling red-shift"

- **A.** was not discovered until the giant Hale telescope was put in use.
- **B.** is so unusual that it has never been explained.
- **C.** is in reality an optical illusion.
- **D.** probably was something to do with relative motion.
- **E.** was first observed in Newton's optical experiments.

289. (3.10) The statement "these lines are shifted about one-twentieth of an inch" is a

- **A.** statement of observed fact.
- **B.** reasonable inference from observation.
- **C.** statement based on theoretical considerations.
- **D.** necessary assumption if the conclusion is correct.

290. (2.10) If lines are shifted toward the longer wavelength end of the spectrum it probably indicates that

- **A.** the light being received by the Hale telescope is different from ordinary light.
- **B.** light from the distant stars is predominantly red in color.
- **C.** the Hale telescope and the light source are not a fixed distance from each other.
- **D.** the Hale telescope is out of adjustment.

291. (2.20) Another explanation of the "red-shift" might be that

- **A.** the red light is bent as it travels through space.
- **B.** the source of light is very distant and the character of the light changes in transit.
- **C.** a red filter on the telescope alters the position of the red lines.
- **D.** red light is bent by the prism more than light of other colors.

292. (2.20) If light loses energy it may be indicated by

- **A.** a fainter record on the photographic plate.
- **B.** an increase in frequency of vibration.
- **C.** the change in position away from the ultra-violet end of the spectrum.
- **D.** a change in position away from the infra-red end of the spectrum.

293. (2.20) "The universe continues to expand" is best classified as

- **A.** an unwarranted assumption.
- **B.** an unsubstantiated guess.
- **C.** a reasonable hypothesis. **D.** a proven fact.

294. (2.20) Chromatic aberration in a single lens is best explained by the statement:

- **A.** The angle of refraction depends upon the wave length of the light.
- **B.** The refractive power varies greatly with the kind of glass used.

C. Light travels more slowly through glass than through air.
D. A lens absorbs some colors better than it does others.
E. The angle of incidence affects the angle of refraction.

295. (2.20) The full moon in winter has a silver color; the full moon in summer has a golden color. This is due to the fact that the

A. moon shines only by reflected light.
B. full moon is nearly overhead in winter while in summer it is near the horizon.
C. atmosphere transmits light more efficiently in summer than in winter.
D. light from the moon travels through a greater distance of air in winter than in summer.
E. moon reflects a greater amount of sunlight in winter than in summer.

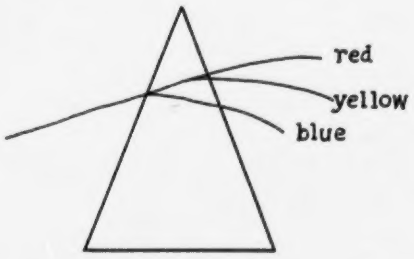
296. (2.20) An individual whose eye trouble is simple far-sightedness is properly fitted with converging lenses. The primary purpose of these lenses is to

A. form a larger image. **B.** form a smaller image.
C. form the image on the retina.
D. send more light through the pupil.
E. increase the power of accommodation.

297. (2.20) In the spectrum produced by a glass triangular prism the red is deviated less than the blue. This indicates that in the glass

A. the speed of red light is greater than that of blue light.
B. the speed of blue light is greater than that of red.
C. the difference of deviation is due to some other cause.

298. (2.20) A beam of white light passes through a glass prism and is dispersed as shown.



The best explanation of this order of dispersion is

A. the prism alters the frequency of blue light more than that of red light.
B. white light is composed of three primary colors.
C. the amount of deviation varies with the type of glass used for the prism.
D. red light moves more rapidly through glass than do the other components of white light.
E. diffraction causes the beam to spread out.

299. (2.20) According to Kirchhoff's explanation of the Fraunhofer lines, the chief use of studying those lines would be to gain information concerning

A. the structure of atoms.
B. the structure of molecules.
C. the nature of radiation.
D. the processes of emission and absorption of radiation.
E. the chemical composition of celestial bodies.

300. (3.00) If sunlight is passed through a flame containing sodium, and if the Fraunhofer D-line is thereby made darker, one concludes that

A. the bright regions in the spectrum of the sunlight are less intense than the light emitted by the sodium flame.
B. the light of the frequency of the sodium line is less intense in the beam of sunlight than in the light emitted by the sodium flame.
C. the dark D-line in the solar spectrum is really brighter than the bright D-line in the spectrum of the flame.
D. the intensity of light of the frequency of the sodium line in the beam of sunlight is zero.
E. the intensity of light of the frequency of the sodium line in the sunlight that has passed through the sodium flame is zero.

301. (2.20) According to Kirchoff and Bunsen, the lines in a bright line spectrum are plainer, the higher the temperature and the weaker the natural illuminating power of the flame. These two conditions together

A. intensify the light constituting the lines, and diminish the intensity of the rest of the spectrum, thus giving a sharper contrast.
B. intensify the light constituting the lines, and produce destructive interference in the rest of the spectrum, thus giving a sharper contrast.
C. minimize the effects of diffraction which might tend to reduce the clarity of the lines, and at the same time make the lines themselves brighter.
D. intensify the brightness of the lines and that of the rest of the spectrum as well, but the former more than the latter.
E. leave unchanged the intensity of the bright lines, but make the rest of the spectrum darker.

302. (2.20) The general proposition set forth as a new discovery by Kirchhoff and Bunsen, in their report of their investigation of spectra, is that

A. certain substances placed in a flame, or otherwise made to emit light, give a spectrum containing bright lines.
B. the capacity of a substance to absorb light of a given frequency is inversely proportional to its capacity to emit such light.
C. the capacity of a substance to absorb light of a given frequency is directly proportional to its capacity to emit such light.
D. the bright lines occurring in the spectra of certain metals are within wide limits determined by the metal, independently of chemical combination and of the process producing the luminosity.
E. no two substances can emit light of the same frequency; thus a study of the light emitted permits an identification of the source.

303. (2.00) One can conclude from this discovery that

A. bright line spectra are due to intra-atomic processes.
B. atoms are capable of only certain discrete energy states.
C. radiation is emitted discontinuously.
D. absorption and emission are processes exactly inverse to one another.
E. none of the above.

304. (2.20) When two beams of white light from different sources —e.g., two flashlight beams, fall upon the same spot, no interference effects are observed. This as explained by Young's wave theory of light is due to the circumstances that

A. white light is composed of many different wave lengths.

B. interference can only be produced by very narrow beams from sources which are practically "points."

C. the phase relations fluctuate in light emitted from different sources, so that at any given point cancellation and reinforcement rapidly alternate, producing for the eye a net uniform effect.

D. light from two different sources cannot have exactly the same frequency, since the vibrations of the particles of bodies are not perfectly regular, and thus the two "white" lights from different sources differ in the precise colors which compose them; but lights of different color cannot produce interference.

E. the speeds of light of different wave lengths are not all the same.

305. (2.20) The interference of light rays is analogous, according to Young, to the phenomenon of "beats" in sound. Yet the latter phenomenon occurs only with two sounds of different frequencies, the former only with two rays of the same frequency. This discrepancy can be understood when one recognizes that

A. beats are a fluctuation in time, caused by a continual shift in the phase relations of the two sounds, which leads to alternate reinforcement and cancellation; interference of light rays is constant in time, varying only from place to place.

B. two light rays never have precisely the same frequency, but the frequency differences required is too small to be detected except by the most sensitive measurements, so the frequencies of the two rays must be "practically" the same.

C. light of different frequencies, having different degrees of refrangibility, must be propagated with different speeds, unlike sounds which are all propagated at the same rate.

D. sound waves are compressional waves, while light waves represent a vibration taking place at right angles to the direction of propagation of the light.

E. the wave length in a light ray is inversely proportional to its frequency.

306. (2.20) Which of the following best expresses Young's experimental law concerning the interference of light?

When a single beam of light is divided into two parts, which, after traveling over different paths, fall upon the same points, bright and dark fringes are formed respectively.

A. at equal intervals.

B. at equal distances from the light source.

C. at points whose distances from the light source, measured along the two paths, differ by an even and an odd multiple of a certain definite length characteristic of the light.

D. at points whose distances from the light source, measured along the two paths differ by an odd and an even multiple of a certain definite length characteristic of the light.

E. at points whose distance from the light source, measured along the two paths form an arithmetic progression whose common difference, the "interval of disappearance," is characteristic of the light.

307. (2.20) According to Huygens, the wave theory of light accounts for the fact that beams of light "cross one another without hindering one another in any way." Yet as Young points out, it is well known that water waves, for example, produce definite "interference" effects when they cross one another. Which of the following is the best comment on this situation?

A. Huygens conceived of light as a compressional wave, not a "transverse" wave as in water where vibrations occur at right angles to the direction of propagation.

B. Huygens conceived the pulses of compression to be spaced irregularly, so that when two series of pulses cross one another it is likely that no actual meeting of wave crests would take place.

C. Huygens was not aware of the existence of interference phenomena.

D. Huygens' point is that the propagation of the waves past the region where they cross is not disturbed by the crossing.

E. Huygens did not base his conclusion upon the analogy to water waves or other sorts of wave motion, but upon the results of his construction of "wavelets" and their common tangents.

308. (2.20) Which of the following is the best formulation of Huygens' most central contribution to our understanding of the nature of light?

A. In order to obtain a genuine understanding of the nature of light, it is necessary to consider not merely the laws of the behavior of light, but also the explanation of these laws in terms of the causes of that behavior.

B. To understand the behavior of light, one must formulate hypotheses which are tested indirectly through their consequences.

C. The refraction of light can be explained as due to a change in its speed when it passes from one transparent medium to another.

D. The direction in which light is propagated from a given point can be regarded as giving the direction of a line perpendicular to the wave front of the light at that point, and conversely.

E. The behavior of light can be accounted for by the terms of a disturbance progagated in all directions from each point, with the disturbances originating from separate points combining to produce the resultant optical state.

309. (2.30) To obtain a good photograph of a certain scene the f-number of a camera is set at 8 and an exposure time of 1/100 second is used. If the f-number is changed to 16, the new exposure time should be (in sec.)

A. 1/25. **B.** 1/50. **C.** 1/100. **D.** 1/200. **E.** 1/400.

Newton defines a ray of light as follows: "By the Rays of Light I understand at least Parts. . . . The least Light or part of Light, which may be stopp'd alone without the rest of the Light, or propagated alone, or do or suffer any other thing alone, which the rest of the Light doth not or suffers not, I call a Ray of Light."

310. (2.30) This conception of a ray presupposes

A. the atomicity of light, i.e., that it consists of a finite number of indivisible parts.
B. that light travels with a finite speed.
C. that light can be regarded as a composite process, consisting of parts which behave independently of one another.
D. that a distinction exists between "part of light" and "path of light."
E. all of the above.

311. (2.40) The steps leading to a swimming pool appear bent where they enter the water because

A. light is diffracted by the surface of the water.
B. light is dispersed on entering the water.
C. light travels with a different speed in air and water.
D. light does not travel in straight lines in water.
E. light is scattered by suspended particles in the water.

312. (3.00) A movie screen set up 20 feet from the film in the projector shows a clear image when the film is 6 in. from the lens. The magnification

A. is 20½ times. **B.** is 39 times. **C.** is 40 times.
D. is 40½ times.
E. cannot be found without the focal length of the lens.

313. (3.00) In a lantern slide projector, the projecting lens is between the slide and the screen. If the slide is 20 feet from the screen and the lens 6 inches in front of the slide, the magnification of the image on the screen is

A. 20½. **B.** 39. **C.** 40. **D.** 41.
E. cannot be found from the data.

Items 314 and 315 refer to lenses. Formula:

$$\frac{1}{p} + \frac{1}{q} = \frac{1}{f}$$

314. (3.00) A concave (diverging) lens forms an image 10 cm. from the lens when the object is 20 cm from the lens. The image will be

A. virtual and smaller than the object.
B. twice the size of the object. **C.** real and erect.
D. on the opposite side of the lens from the object.
E. inverted but diminished in size.

315. (3.00) When an object is placed 4 cm. from a convex (converging) lens it forms a virtual image 20 cm. from the lens. The focal length of the lens is

A. 5 cm. **B.** −3⅓ cm. **C.** ⅓ cm. **D.** 3⅓ cm.
E. none of these.

316. (3.00) If a 100 candle power bulb gives satisfactory illumination on a surface at a distance of 10 feet, at what distance would a 400 candle power bulb give equal illumination?

A. 2.5 feet. **B.** 20 feet. **C.** 7.5 ft. **D.** 40 ft.
E. 10 ft.

317. (3.00) If a person who is reading at a distance of 2 feet from a 100 watt lamp bulb moves to a distance of 4 feet from the bulb,

A. the brightness of illumination will be ½ as great.
B. the candlepower will be decreased to ¼ as much.
C. the number of foot candles will be 1/16 as great.
D. the intensity of illumination will be ¼ as great.
E. the watts per candle power will be ½ as great.

318. (3.00) If a person, who is reading at a distance of 9 ft. from a 100 watt lamp, changes his position so that he is 3 ft. from the lamp

A. the brightness of the source will be three times as great.
B. the candle power will be increased nine times.
C. the number of foot candles will be six times as great.
D. the intensity of illumination will be nine times as great.
E. the efficiency in watts per candle power will be six times as great.

319. (3.00) The distance from the earth to the moon is about 1/400th of the distance from the earth to the sun. If the sun were found at the moon's distance, the illumination of the earth would be increased,

A. 1/800 times. **B.** 400 times. **C.** 800,000 times.
D. 200 times. **E.** 160,000 times.

320. (3.00) If a single lamp bulb 1 ft. away from a surface gives satisfactory illumination, how many lamp bulbs of equal candle power would be needed to give equal illumination when the distance is 4 ft.?

A. 2. **B.** 4. **C.** 8. **D.** 16. **E.** 32.

321. (3.00) The best explanation of why a pin-hole camera can give a sharp image comparable to that of a box-camera with a lens is the fact that

A. light is a wave motion.
B. light travels in straight lines.
C. light can be diffracted.
D. light can produce interference phenomena.
E. light can be reflected without a lens.

Items 322 - 327 involve the images formed by a converging lens of focal length 10 cm. Select from the key the condition necessary to produce the effect stated by each item.

KEY

A. Object placed at the focal point in front of the lens.
B. Object placed 12 cm. from the lens.
C. Object placed 8 cm. from the lens.
D. Object placed 100 cm. from the lens.
E. Object placed 20 cm. from the lens.

		Disc.	Diff.
322. (3.00)	Image is the same size as the object.	.10	88.3
323. (3.00)	Real inverted image is smaller than the object.	0	85
324. (3.00)	Image rays are parallel.	0	83.3
325. (3.00)	Image is virtual and magnified.	.14	76.7
326. (3.00)	Image is real and larger than the object.	0	95
327. (3.00)	Image is erect and virtual.	.50	95

328. (3.00) When an object is placed 4 cm. in front of a converging lens with a focal length of 5 cm., the image distance is

A. 1 cm. **B.** 20 cm. **C.** −20 cm. **D.** −5 cm.
E. 2.2 cm.

329. (3.00) Which one of these statements is true for a lens which is forming a virtual image?

- **A.** It may be projected on a screen.
- **B.** It is formed when two or more rays from the same part of the object diverge after refraction.
- **C** It is formed whenever two or more rays from the same part of the object converge before striking the lens.
- **D.** It is formed whenever two or more rays from the same part of the object converge after passing through the lens.
- **E.** A virtual image is inverted after refraction takes place.

330. (3.00) If a beam of yellow light is produced by combining beams of red and green and the yellow light falls on a red screen, the screen appears red. But if only yellow sodium light falls on the red screen, the screen appears black because

- **A.** the red screen disperses yellow light.
- **B.** the red screen absorbs the yellow light of sodium.
- **C.** the red screen reflects all colors except red.
- **D.** the wave length of red light includes a lot of other wave lengths.
- **E.** the red screen refracts yellow light.

331. (3.00) A driver accused of going through a red light claimed as his defense that his motion toward the light gave him a Doppler effect and the red light appeared green.

The judge should

- **A.** acquit him because such a defense is valid.
- **B.** convict him because the Doppler effect does not exist in light.
- **C.** acquit him because the driver was obviously scientific and hence was a reliable person.
- **D.** convict him because at present no person can travel fast enough to be able to observe the Doppler effect in light.
- **E.** convict him because he was color blind and should not have a driver's license.

332. (3.00) Assuming that one clear night the moon exploded

- **A.** we would see the explosion but never hear the sound of it.
- **B.** we would hear the sound at the same time as we saw the explosion.
- **C.** we would see the explosion before we heard the sound.
- **D.** we would be able to calculate the distance of the moon to the earth by timing the interval between seeing and hearing the explosion.
- **E.** since the moon can only reflect light, we would not be able to see the explosion.

333. (1.10) At sunset and sunrise the color of the sun appears different than at high noon because

- **A.** the sun emits lower wave lengths in the morning and evening.
- **B.** the sun emits lower wave lengths at noon.
- **C.** our retinas react differently as we become more fully awakened and before they get too tired.
- **D.** the sun's light passes through a greater thickness of atmosphere during the morning and night than at noon.

Items 334 - 336 refer to the following table of data for placing the object at various positions in front of a converging lens (convex). Several spaces are filled in to show the nature of the responses. The abbreviation *f* stands for focal distance.

Object Position	Image Position	Size of Image	Description
I. At infinity		Infinitesimal	Real, inverted
II. At twice the f dist.	At 2 f on opp. side		
III. Greater than 2 f			
IV. Between f and 2 f			
V. At principal focus			

334. (3.00) In which one of the above object positions would the image be described as erect?

A. II. **B.** III. **C.** IV. **D.** V.
E. None of these positions.

335. (3.00) In which one of the above object positions would the image size be greater than the object size?

A. II. **B.** III. **C.** IV. **D.** V.
E. None of the above.

336. (3.00) When the object is placed at infinity, the image position is

- **A.** between f and 2 f on the opposite side of the lens.
- **B.** at infinity on the opposite side of the lens.
- **C.** at f on the same side of the lens as the object.
- **D.** at the principal focus on the opposite side of the lens.
- **E.** indeterminate.

Items 337 and 338 refer to the following. A boy found an old box camera which had a fixed focus simple convex lens, a shutter for snap shots, and a diaphram (metal plate with a small hole in it and placed in front of the lens). He decided to make the diaphram hole larger hoping to improve the camera.

337. (3.00) This change would

- **A.** change the focal length of the lens.
- **B.** increase spherical aberration.
- **C.** increase exposure time in taking pictures.
- **D.** increase the size of the pictures.
- **E.** eliminate chromatic aberration.

338. (3.00) If he took a picture with infra-red light and infra-red film in an otherwise darkened room, the lens would

- **A.** have less spherical aberration.
- **B.** have no astigmatism.
- **C.** have less chromatic aberration.
- **D.** produce no picture. **E.** produce an erect image.

Items 339 and 340 refer to the difficulties a boy has in reading. He can read the blackboard but when he reads books the words blur over. However, he can read books if he holds them at arm's length.

339. (3.00) The doctor will probably recommend glasses with

- **A.** concave lenses. **B.** cylindrically ground lenses.
- **C.** lenses which have different curvatures, at different places.
- **D.** convex lenses. **E.** prismatically ground lenses.

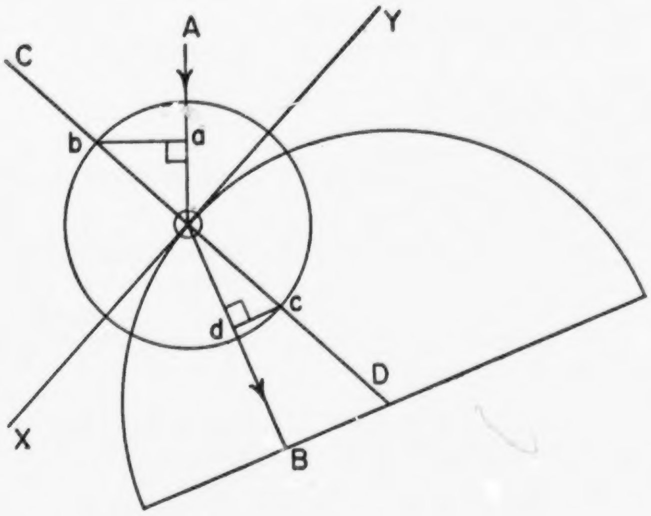
340. Because
(3.00)

- **A.** the use of lenses with different curvatures eliminates blurring of the print.
- **B.** the point at which the light rays converge is moved from behind the retina to the surface of the retina.
- **C.** astigmatism is corrected by the use of cylindrically ground lenses.
- **D.** unusual muscle strain is generally corrected by a prismatic lens.
- **E.** the light rays must be diverged in order to focus on the retina.

341. Monochromatic yellow light falls upon a sheet of white
(3.00) paper ruled with blue lines. As a result the paper

- **A.** and blue lines appear black.
- **B.** appears white and the lines black.
- **C.** looks yellow but the lines are invisible.
- **D.** and the lines appear yellow.
- **E.** appears yellow and the lines black.

Items 342 - 344 refer to the diagram of the path of a light ray AB.



342. The angle of incidence is
(2.10)

A. AOY. **B.** AOC. **C.** BOX. **D.** BOD.
E. COX.

343. The angle of refraction is
(2.10)

A. AOY. **B.** BOD. **C.** BOX. **D.** AOC.
E. COX.

344. The index of refraction of the lens is
(3.00)

A. $\frac{Ob}{oc}$ **B.** $\frac{oa}{od}$ **C.** $\frac{ab}{cd}$ **D.** $\frac{cd}{ab}$
E. none of these.

345. A blot of red ink is spilled on a drawing made with
(3.00) black India ink on white paper. How may this drawing be photographed in such a way that the blot will not appear on the picture? (Assume that the film used in the camera is sensitive to all colors of light.)

- **A.** Under white light with a blue-green filter over the lens.
- **B.** Under white light with a red filter over the lens.
- **C.** Under red light with a blue-green filter over the lens.
- **D.** Under blue-green light with no filter over the lens.
- **E.** There is no way that the blot can be kept from showing up in the picture.

346. If a thin gold leaf is placed on a sheet of white paper
(3.00) and illuminated with white light, the leaf appears to have a reddish color; however, if a white object is viewed through the leaf, the object appears green. This can be explained if we assume that the gold leaf

- **A.** reflects green and red light.
- **B.** transmits green and red light.
- **C.** transmits green light and absorbs the other colors.
- **D.** absorbs red light and transmits the other colors.
- **E.** reflects red light and transmits the other colors.

Items 347 - 349 involve the images formed by a converging lens of focal length 10 cm. Select from the key the condition necessary to produce the effect stated by each item.

KEY

- **A.** Object placed at the focal point in front of the lens.
- **B.** Object placed 12 cm. from the lens.
- **C.** Object placed 8 cm. from the lens.
- **D.** Object placed 100 cm. from the lens.
- **E.** None of these.

347. Real inverted image, larger than the object.
(3.00)

348. Image rays are parallel.
(3.00)

349. Virtual image, smaller than the object.
(3.00)

350. A diverging lens of focal length 15 cms. and a converg-
(3.00) ing lens of focal length 60 cms. are cemented together. The focal length of the combination is

A. −12 cms. **B.** −20 cms. **C.** −30 cms.
D. −45 cms. **E.** −75 cms.

351. A 100-watt lamp delivers 1.25 candle power per watt.
(3.00) If a student requires at least 5 foot-candles of illumination to read comfortably, the distance from lamp to book should not exceed

A. 1 ft. **B.** 5 ft. **C.** 25 ft. **D.** 125 ft.
E. 400 ft.

Items 352 - 355. Given an object 12 in. high and 4 ft. in front of a vertical plane mirror.

352. The distance from the object to the image is
(3.00)

A. 2 ft. **B.** 4 ft. **C.** 6 ft. **D.** 8 ft. **E.** 16 ft.

353. The image is
(3.00)

A. real. **B.** inverted. **C.** indistinct.
D. quite invisible. **E.** virtual.

354. The height of the image is
(3.00)

A. 7½ in. **B.** 12 in. **C.** 15 in.
D. 30 in. **E.** 4 ft.

355. The image is
(3.00)

A. on the mirror. **B.** in front of the mirror.
C. above the mirror. **D.** below the mirror.
E. behind the mirror.

356. (3.00) A piece of yarn which appears deep red under white light will appear

A. black under blue light. **B.** black under red light.
C. white under blue light. **D.** red under blue light.
E. white under red light.

357. (3.00) If a yellow-green paint is mixed with a blue-green paint the color of the mixture will probably be

A. red. **B.** black. **C.** white. **D.** orange.
E. green.

358. (3.00) A slide two inches square is used in a lantern which has a projection lens having a focal length of 8 inches. If the screen is nearly filled by the image when placed 16 ft. from the lantern, it should have a width of approximately

A. 3.5 ft. **B.** 4 ft. **C.** 4.5 ft. **D.** 5 ft.
E. 5.5 ft.

359. (3.00) A thin glass lens, with a concave and convex surface, is thinner at the edges than at the center. If the radii of curvature are 20 cms. and if the refractive index at the glass is 1.5, the focal length of the lens is

A. 20 cms. **B.** −30 cms. **C.** 30 cms.
D. −60 cms. **E.** 60 cms.

An object which is 1 ft. long stands 2 ft. in front of a converging lens. The focal length of the lens is 3 ft.

360. (3.00) The image is located

A. 2 ft. in front of the lens. **B.** 3 ft. behind the lens.
C. 3 ft. in front of the lens. **D.** 6 ft. behind the lens.
E. 6 ft. in front of the lens.

361. (3.00) The nature of the image is

A. real and erect. **B.** real and inverted.
C. virtual and inverted. **D.** virtual and erect.
E. none of the above.

362. (3.00) The length of the image is

A. 1 ft. **B.** 3 ft. **C.** 6 ft. **D.** 12 ft.
E. 24 ft.

An object which is 3 cm. long stands 6 cm. in front of a diverging lens. The focal length of the lens is 3 cm.

363. (3.00) The image is located

A. 2 cm. in front of the lens.
B. 2 cm. behind the lens.
C. 3 cm. in front of the lens.
D. 3 cm. behind the lens.
E. 6 cm. in front of the lens.

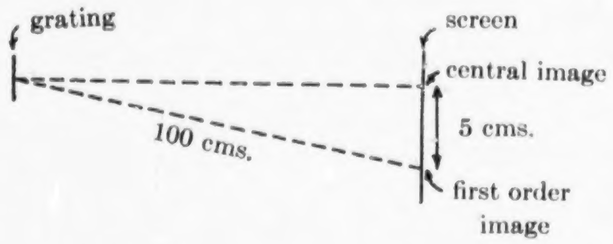
364. (3.00) The nature of the image is

A. real and erect. **B.** real and inverted.
C. virtual and inverted. **D.** virtual and erect.
E. none of the above.

365. (3.00) The length of the image is

A. 1 cm. **B.** 2 cm. **C.** 3 cm. **D.** 6 cm.
E. 12 cm.

A diffraction grating is used to form the spectrum of an unknown light source. A first order image is found 5 cm. from the central image and 100 cm. from the grating. The grating has 1000 lines per centimeter.



366. (3.00) What is the grating element (grating space)?

A. .001 cm. **B.** .05 cm. **C.** .72 cm.
D. 500 cm. **E.** 1000 cm.

367. (3.00) What is the wave length of the light?

A. 5×10^{-5} cm. **B.** 2×10^{-4} cm.
C. 5×10^{-3} cm. **D.** 20 cm. **E.** 2000 cm.

368. (3.00) Light from a distant object falls on a converging lens of 17 cm. focal length. A diverging lens of 20 cm. focal length is placed 2 cm. behind the converging lens. The final image is located behind the diverging lens at a distance of

A. 20 cm. **B.** 40 cm. **C.** 60 cm. **D.** 80 cm.
E. 100 cm.

369. (3.00) A converging lens of focal length 6 inches is inserted in the path of a beam of converging rays of light. If the lens is one foot from the point of convergence of the incident beam, the image is

A. non-existent. **B.** 4 inches in front of the lens.
C. 4 inches behind the lens.
D. 12 inches in front of the lens.
E. 12 inches behind the lens.

Item 370 deleted.

371. (3.00) The combination of two thin lenses placed in contact with their principal axes coincident is, if one is a converging lens of 20 cms. focal length and the other a diverging lens of 30 cms focal length

A. a converging lens of 60 cms. focal length.
B. a diverging lens of 60 cms. focal length.
C. a diverging lens of 50 cms. focal length.
D. a converging lens of 50 cms. focal length.
E. a converging lens of 10 cms. focal length.

372. (3.00) Suppose that an instrument of a certain kind is capable of detecting optical processes at a single point. To which of the characteristics of light might it be directly sensitive?

A. Wave length. **B.** Velocity. **C.** Frequency.
D. Refrangibility. **E.** All of the above.

373. (3.00) Suppose that an instrument is provided which is capable of detecting optical processes at all the points of an extended region at a single instant of time. To which of the characteristics of light might it be directly sensitive?

A. Wave length. **B.** Velocity. **C.** Frequency.
D. Refrangibility. **E.** None of the above.

374. In view of the considerations brought forth in the two
(3.00) preceding questions, and of the nature of the eye as an optical instrument, one would expect an eye to be sensitive to

A. the wave length of light. **B.** the velocity of light.
C. the frequency of light.
D. the refrangibility of light. **E.** the color of light.

375. The answer to the preceding question enables one, in
(3.00) considering a beam of light which is a monochromatic green in air, to conclude

A. that its color is shifted toward the red when it enters an optically denser medium.
B. that its color is shifted toward the blue when it enters an optically denser medium.
C. that its color is shifted when it enters an optically denser medium; the direction of the shift cannot be predicted from the considerations given.
D. nothing concerning its color in an optically denser medium.
E. that its color is unchanged when it enters an optically denser medium.

376. From the preceding four questions, one can conclude
(2.00)

A. that the brightness of a beam of light depends upon its refrangibility.
B. that the brightness of a beam of light depends upon its velocity.
C. that the brightness of a beam of light depends upon its wave length.
D. that the brightness of a beam of light depends upon its frequency.
E. nothing concerning the factors influencing the brightness of light.

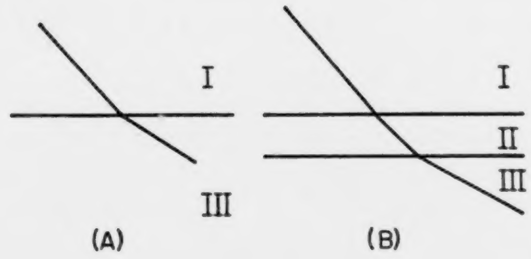
377. On the basis of Young's theoretical explanation of the
(3.00) law of interference, one should expect that, if homogeneous light is made to produce interference effects in two different media (e.g., air and glass), the "interval of disappearance" will be

A. the same in both media.
B. smaller in the medium in which the light travels faster, the difference in the intervals of disappearance being equal to the difference in speed.
C. greater in the medium in which the light travels faster, the difference in the intervals of disappearance being equal to the difference in speed.
D. directly proportional to the speed of the light.
E. inversely proportional to the speed of the light.

378. If light passes through a single narrow slit and falls
(3.00) upon a screen, a certain region is illuminated. If the light passes through two such slits side by side, certain portions of the screen previously illuminated by either slit alone are now in darkness. In view of the fact that light carries energy, one may conclude that

A. the total energy falling upon the screen is diminished, in the case of the two slits, by the interference of the light.
B. since the total energy falling upon the screen must be the sum of the quantities of energy flowing through each slit, the intensity of illumination at certain places on the screen must be more than the sum of the intensities which would be produced by each slit alone.
C. the intensity of illumination on the screen is due to an interaction of two light rays which have, at equal distances, opposite properties capable of destroying one another.
D. light is not in all cases propagated in straight lines, even in a homogeneous medium.
E. the absence of illumination does not always indicate the absence of light energy; this may be "latent," due to the destructive interference of two rays, but it is present nevertheless, as is evident from the fact that it is propagated past the dark place.

379. It is proposed, as a hypothesis, that a ray of light passing
(3.00) from medium I to medium III (figure A) emerges in the same direction as it would if a layer of medium II were interposed between the parallel surfaces of I and III (figure B).



The correctness of this hypothesis

A. follows from the wave theory of light, on the basis of the relationships considered in the preceding three questions.
B. follows from the wave theory of light, on the basis of Young's principle of interference.
C. is incompatible with the wave theory of light, on account of the relationships considered in the preceding three questions.
D. is incompatible with the wave theory of light, on account of consequences which follow from Young's principle of interference.
E. cannot be judged on the basis of the general postulates of the wave theory but requires a separate experimental investigation.

380. The "optical density" of transparent media is defined,
(2.10) as a *comparative* concept, in accordance with Newton's Axiom IV: refraction out of the rarer medium into the denser is made towards the perpendicular. Which of the following would serve well as a quantitative measure of the optical density of a medium (say, of medium I)?

A. $n_{I,vac}$.
B. $n_{vac,I}$.
C. $n_{I,I}$.
D. $n_{I,vac}n_{vac,I}$.
E. $n_{I,vac} - n_{vac,I}$.

381. In terms of this quantitative measure, the optical density
(2.10) of a vacuum must be considered to be

A. +1. **B.** +½. **C.** 0. **D.** −½. **E.** −1.

Let $n_{I,I}$ represent the ratio of the sine of incidence to the sine of refraction for light going from medium I into medium II. In particular, let $n_{vac,I}$ represent that ratio for light going from a vacuum into medium I, $n_{I,vac}$ the corresponding ratio for light going from medium I into a vacuum. Further, let the speed of light in a given medium be represented by the letter q with an appropriate subscript.

382. Which of the following relationships holds, according
(1.10) to the wave theory of light?

A. $q_{I} = n_{I,II}q_{II}.$ **B.** $q_{II} = n_{I,II}q_{I}.$
C. $n_{I,II} = q_{I}q_{II}.$ **D.** $q_{I}n_{I,II}q_{II} = 1.$
E. $\frac{q_{I}}{q_{II}} = \frac{q_{III}}{n_{I,III}n_{.II,III}}$

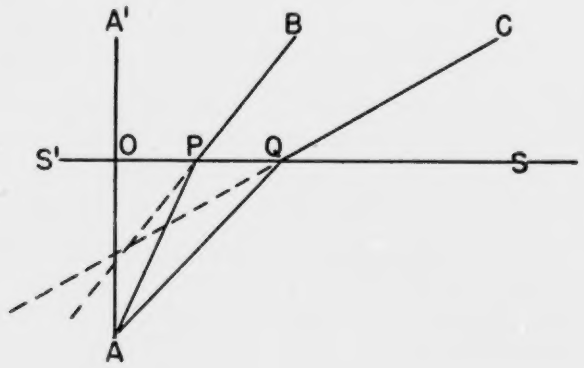
383. Consequently, the quantity $n_{I,II}$ characterizing a pair
(3.00) of media I and II, can be calculated from the quantities referring to each medium together with a vacuum, as follows:

A. $n_{I,II} = \frac{n_{vac,I}}{n_{vac,II}}$ **B.** $n_{I,II} = \frac{n_{I,vac}}{n_{vac,II}}$
C. $n_{I,II} = \frac{n_{vac,I}}{n_{II,vac}}$ **D.** $n_{I,II} = ({}^{n}\mathrm{vac,I}{}^{n}\mathrm{vac,II})^2$
E. ${}^{n}\mathrm{vac,I}{}^{n}\mathrm{vac,II}{}^{n}\mathrm{I,II} = 0$

384. If we consider the passage of light between each pair
(3.00) selected from a set of three media, I, II and III, we should expect to find that

A. $n_{I,II} = n_{I,III}n_{II,III}.$ **B.** $n_{II,III} = n_{I,II}n_{I,III}.$
C. $n_{I,III} = n_{I,II}n_{II,III}.$ **D.** $(n_{I,II})^2 = n_{I,III}n_{II,III}.$
E. $n_{I,II} = (n_{I,III}n_{II,III})^2.$

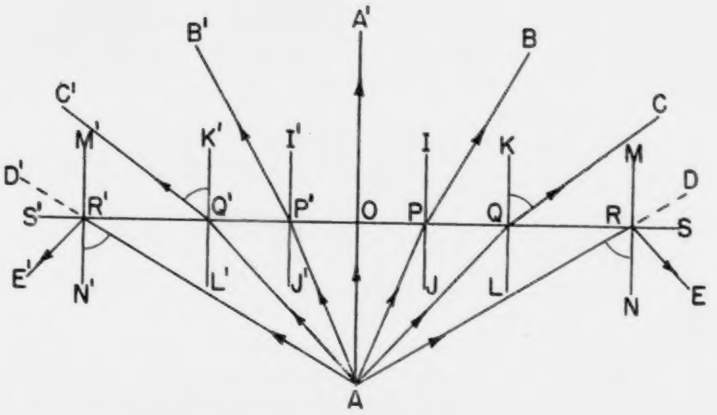
385. The accompanying diagram indicates the relationship
(3.00) of the backward extensions of the several refracted rays coming from point A the water's surface. According to this, if the object at A is viewed by an eye in the air from positions successively farther to the right, its image will appear



A. always in the same place, but more and more blurred.
B. successively higher, but always on the line AO.
C. successively higher and farther toward the right.
D. successively higher and farther toward the left.
E. successively lower and farther toward the left.

Items 386 - 394.

In the accompanying diagram, SS' represents the surface of a body of still water. A is a point in the water, from which light rays are represented as following the paths AO A', APB, AP'B', AQC, AQ'C', ARE, and AR'E'. The straight lines AA', IJ, I'J', KL, K'L', MN, and M'N' are perpendicular to the surface SS'. The dotted lines RD and R'D' are extensions of the lines AR and AR'. The angles NRA and N'R'A' are equal to one another as well as to the angles KQC and K'Q'C'; the value of these angles is the "critical angle" for the pair of media, water and air. In the following questions, attention will be restricted to points in the plane of this diagram.



386. Which of the following equalities holds?
(1.20)

A. $\frac{\sin \measuredangle CQK}{\sin \measuredangle RQL} = \frac{\sin \measuredangle BPI}{\sin \measuredangle APJ}$
B. $\frac{\sin \measuredangle AP'J'}{\sin \measuredangle AQL} = \frac{\sin \measuredangle CQK}{\sin \measuredangle B'P'I'}$
C. $\frac{\sin \measuredangle AOS}{\sin \measuredangle A'OS'} = \frac{\sin \measuredangle APJ}{\sin \measuredangle BPI}$
D. $\frac{\sin \measuredangle DRM}{\sin \measuredangle ARN} = \frac{\sin \measuredangle CQK}{\sin \measuredangle AQL}$
E. $\frac{\sin \measuredangle BPI}{\sin \measuredangle APJ} = \frac{\sin \measuredangle C'Q'K'}{\sin \measuredangle AQ'L'}$

387. Total reflection is represented as occurring at points R
(3.00) and R'. It may be expected to occur

A. at all points between R and R'.
B. at all points between Q and R, and at all points between Q' and R'.
C. at all points to the right of Q and at all points to the left of Q'.
D. at all points to the right of R and at all points to the left of R'.
E. at all points to the right of some point between R and Q, and at all points to the left of some point between R' and Q'.

388. Total reflection would not occur at the point R if the
(3.00) source of light were moved from the point A

A. vertically, upward toward O.
B. horizontally to the left.
C. horizontally, to the right.
D. along the line AR, toward R.
E. along the line AR, away from R.

389. An eye at the point A would be able to see an object
(3.00) in the air

A. only if it were within the region bounded on the right by RD and on the left by R'D'.
B. only if it were within the region bounded on the right by QC and on the left by Q'C.
C. only if it were within a region bounded on the right by a line somewhere between QC and RD, and on the left by one somewhere between Q'C' and R'D'.
D. unless it were within the region between RD and QC, or between R'D' and Q'C'.
E. in any position whatever.

390. For an eye at the point A to see in the air,
(3.00)

A. it must look in the direction of a point on the surface between Q and Q'.
B. it must look in the direction of a point on the surface between R and R'.

C. it must look in the direction of a point on the surface between two bounding points, which themselves lie respectively between Q and R, and between Q′ and R′.
D. it must look in the direction of a point on the surface which does not lie between Q and R, nor between Q′ and R′.
E. it may look in any direction toward the air.

391. (3.00) An eye at the point D would be able to see an object in the water

A. only if it were in the region to the left of the line RA, or to the right of a corresponding line through D on the other side.
B. only if it were to the right of the extension below the water of the line CQ and to the left of a corresponding line on the other side of D.
C. only if it were to the left of a line parallel to DR and meeting the surface of the water at a certain point between R and Q, or to the right of a corresponding line on the other side of D.
D. only if it were to the right of a line parallel to DR and meeting the surface of the water at a certain point between R and Q and to the left of a corresponding line on the other side of D.
E. in any position whatever.

392. (3.00) For an eye at the point D to see into the water,

A. it must look in the direction of a point on the surface to the left of R, or to the right of a corresponding point on the other side of D.
B. it must look in the direction of a point on the surface to the right of Q and to the left of a corresponding point on the other side of D.
C. it must look in the direction of a point on the surface to the left of a certain point between R and Q and to the left of a corresponding point on the other side of D.
D. it may look in any direction toward the water.

393. (3.00) Let the ratio of the sine of incidence to the sine of refraction, for light going from water to air, be represented by k. The fact that angles KQC and NRA are equal to the critical angle for this pair of media implies that

A. $\sin \measuredangle NRA = k$. **B.** $\sin \measuredangle NRA = 1/k$.
C. $\frac{\sin \measuredangle KQC}{\sin \measuredangle LQA} = k$. **D.** $\frac{\sin \measuredangle LQA}{\sin \measuredangle KQC} = k$.
E. $\frac{\sin \measuredangle DRS}{\sin \measuredangle NRA} = 1/k$.

394. (1.10) Which of these equations would hold, even if angle NRA and angle KQC were not equal to the critical angle?

A. $\sin \measuredangle NRA = k$. **B.** $\sin \measuredangle NRA = 1/k$.
C. $\frac{\sin \measuredangle KQC}{\sin \measuredangle LQA} = k$. **D.** $\frac{\sin \measuredangle LQA}{\sin \measuredangle KQC} = k$.
E. None of the above.

395. (4.10) The concept which plays a role in Huygens' theory of light most analogous to that played by "ray" in Newton's treatment is that of

A. an ether particle.
B. a line perpendicular to a train of wave fronts.
C. a small line segment perpendicular to a wave front.
D. a compression in the ether, organized coherently over a wave surface.
E. the velocity of light in a given medium.

396. (4.10) The existence of the distinction between homogeneous and heterogeneous light is established by

A. the definition itself of homogeneous light ("whose Rays are all alike Refrangible") and heterogeneous light ("whose Rays are some more refrangible than others").
B. the law of refraction.
C. the existence of colors of various hues.
D. the existence of colors not present in the spectrum.
E. Newton's experiment of passing various parts of the spectrum separately through a prism.

Select from the key the appropriate response for each of the items below:

KEY

A. The statement is warranted.
B. The statement is unwarranted.
C. The statement is a reasonable hypothesis.

397. (4.20) ( ) The shorter wave lengths of sunlight that are directed to the surface of a piece of gold penetrate into the metal a distance equal to several layers of molecules.

398. (4.20) ( ) Gold will reflect a golden color regardless of the color of light that illuminates it.

399. (4.20) ( ) When light falls upon a black object the energy is converted into ultra-violet light (black light).

400. (4.20) ( ) When light falls upon a black object the energy is changed to heat (infra-red).

401. (4.20) ( ) One may get an approximate temperature of the moon by observing its color.

402. (4.20) ( ) At a distance of ten miles above the earth the ultra-violet rays are much more intense than at the earth's surface since short waves are scattered by foreign particles in the atmosphere.

403. (4.20) ( ) Accepting Einstein's theory as related to the sun's energy, at the surface of the sun the radiation should be made up of heat, light, ultra-violet light, X-Rays and gamma rays.

404. (4.20) In the statement: A concave lens must be thinner at the center than the edges because it converges the light rays,

A. the first part of the statement is true, and its truth is supported by the reason given in the statement.
B. the first part is true, but its truth is *not* supported by the reason given.
C. the first part of the statement is false.

For items 405 - 409 select from the key the most appropriate statement.

KEY

A. *Statement true; reason true* and bears directly on the statement.
B. *Statement true; reason false.*
C. *Statement true; reason true,* but does not have any bearing on the statement.
D. *Statement false; reason true* but with no bearing on the statement.
E. *Statement false; reason false.*

405. A current results when light falls on a photoelectric cell
(4.20) *because* certain substances emit electrons when light strikes them.

406. Potassium is used in a photoelectric cell *because* it is a
(4.20) metal.

407. Photoelectric cells may be used as exposure meters in
(4.20) photographic work *because* the current in the cell is proportional to the amount of incident light and not to the frequency of the vibration.

408. A simple photoelectric cell has an uncoated plate
(4.20) charged negatively *because* such a plate is necessary to attract the protons released by the incident light.

409. Light striking a photoelectric cell sets up an electric
(4.20) current *because* light is a longitudinal vibration.

410. Various terms are applied to describe the character of
(4.20) the light reflected from the surface of a mineral. Which word includes all the others?

A. Luster. **B.** Earthy. **C.** Metallic.
D. Vitreous. **E.** Pearly.

Items 411 - 415 refer to the paragraph below.

Light is radiant energy which is capable of affecting the eye to produce vision. White light is in reality composed of many colors blended together, that is to say, many electromagnetic energy waves of varying frequencies. These waves belong to a great family of energy waves that propagate through an electromagnetic field and include in increasing lengths and decreasing frequencies; cosmic, gamma, X, ultra violet, visible, infra-red, heat and radio waves. The whole family is propagated at a velocity of 186,000 miles per second as expressed by the equation velocity = frequency × wave length.

After each item number on the answer sheet, blacken space

A. if the statement is true and the explanation of the statement is correct.
B. if the statement is true but the explanation of the statement is not correct.
C. if the statement itself is false.

411. Frequency in visible light corresponds to pitch in sound,
(4.20) because in both sound and light it is the number of complete vibrations per unit of time.

412. The energy radiated from the sun is largely infra-red
(4.20) rays, visible light, and ultra-violet rays, because the wave-lengths of light change while passing through space.

413. We cannot see ultra-violet rays, because the frequency
(4.20) at which they are emitted cannot be picked up by our retinas as can those of white light ray components.

414. X-rays travel faster than ordinary light. This is neces-
(4.20) sarily true since X-rays are more penetrating than ordinary light.

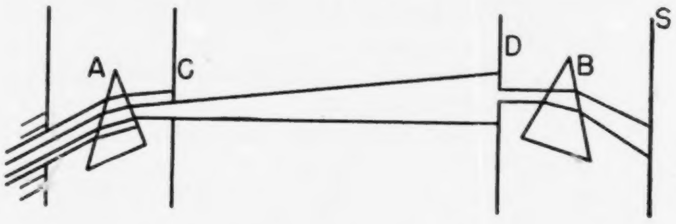
415. Radio waves are extremely long, because they are propa-
(4.20) gated, at the low frequency end of the electromagnetic spectrum.

416. We have long been told that the blue color of sea water
(4.20) is a result of the diffraction of light by molecules of water. But Dr. F. A. Jenkins and Dr. I. S. Bowen came up with another answer as an incidental result of their research for the U. S. Navy in 1941. Their efforts to use light as an anti-submarine device were blocked because light rays penetrated only 580 feet. The reason, an ultra-microscope revealed, is that each cubic inch of the clearest water contains about 1,500,000 dust-like particles. It is largely these particles that reflect light. Most of the light that gets to the surface is composed of blue and violet rays; yellow and red are largely absorbed by the water. From this, we should conclude that

A. it is impossible to explain the blue color of sea water.
B. the diffraction of light by water molecules can no longer be used to explain the blue color of sea water.
C. the blue color of sea water is due solely to reflection of light from dust-like particles and selective absorption of the yellow and red rays.
D. the blue color of sea water is due to a combination of effects; diffraction of light by water molecules, and reflection by dust-like particles accompanied by selective absorption.
E. further experiments should be performed to determine the correct explanation for the blue color of sea water.

Items 417 - 423.

The accompanying diagram represents Newton's "crucial experiment" on colors: A and B are glass prisms, C and D are two boards, each with a small hole. In the experiment, the prism A is rotated, and the image on the screen S is observed.



417. In the spectrum produced by prism A, the colors are
(1.10) arranged alongside one another

A. vertically, with violet at the top.
B. vertically, with violet at the bottom.
C. horizontally, with violet either at the left or at the right, depending on the orientation of the prism.
D. horizontally, with violet at the left for an observer looking from the prism to the screen.
E. horizontally, with violet at the right for an observer looking from the prism to the screen.

418. When prism A is rotated so as to raise the image it casts
(3.00) upon C and D, the image on S will

A. move to the left. **B.** move up.
C. move to the right. **D.** move down.
E. remain stationary.

419. The purpose of rotating prism A was
(4.20)

A. to cause the angle of incidence on prism B to vary.
B. to observe the spectrum produced by different angles of incidence on A.
C. to permit various colors successively to pass through prism B.
D. to discover whether the outside of the light beam, at its "termination with shadow," gives different results than the inside.
E. to discover whether, by mixing the various colors again, white light could be produced.

420. This purpose could have been accomplished also by
(4.20)

A. moving prism B up and down.
B. moving prism A up and down.

C. moving board C up and down.
D. removing board C, and moving D up and down.
E. rotating prism B.

421. (4.20) The method proposed in the answer to the preceding question

A. would be disadvantageous, in that it would lead to a wider and less homogeneous beam of light passing through prism B.
B. would be disadvantageous, in that it would not achieve constancy of the direction of light falling on prism B.
C. would be advantageous, in that it would avoid the need to change the angle of incidence of the light upon prism A.
D. would be advantageous, in that it would produce the desired result without narrowing the beam of light twice, hence without diminishing its brightness as much.
E. would have no serious advantages or disadvantages in relation to the method Newton adopts, but would be somewhat more difficult to carry out by purely manual manipulation of the apparatus.

422. (4.20) The use of two boards, rather than one, to limit the beam of light in this experiment,

A. is redundant, since board C alone would accomplish the same purpose.
B. is redundant, since board D alone would accomplish the same purpose.
C. is redundant, since either board alone would accomplish the same purpose.
D. is necessary in order to insure sufficient homogeneity of the light passing through B.
E. is necessary in order to insure that the light falls upon B with a constant direction, while A is being manipulated.

423. (4.20) Which of the following conclusions is *not* directly supported by the observations made in the course of this experiment?

A. The production of a spectrum from white light consists in a sorting out of rays of different refrangibility.
B. Rays of diverse color differ in refrangibility.
C. It is possible to produce light which is approximately uniform in refrangibility, and such light is not "dispersed" by a prism.
D. The light which goes to the top of the spectrum produced by a prism situated as is A in the above diagram, is light of lower refrangibility than the remainder which goes to lower parts of the spectrum.
E. None of the above, since *each* of the conclusions stated *is* directly supported by the experiment.

424. (4.20) The importance for Newton's discussion of the distinction between homogeneous and heterogeneous light comes from the circumstance that

A. homogeneous light obeys the law of refraction strictly (the ratio of the sines is accurately constant), heterogeneous light only approximately.
B. homogeneous light produces the primary, or "pure," colors, and so represents the basic cause of visual phenomena—i.e., the least part, out of which all other light is composed.
C. the rays of homogeneous light cannot be separated from one another.
D. heterogeneous light explains how it is that visual colors exist which do not occur in the spectrum.
E. homogeneous and heterogeneous light differ as do pure substances and mixtures in chemistry.

Items 425 - 429 refer to two theories that are used at the present time to explain the nature of light and other electromagnetic radiation. The first of these theories is the wave theory which proposes that all electromagnetic radiation consists of waves whose period and frequency coincide with the period and frequency of the source which gives rise to the waves. The second of the theories is the corpuscular or quantum theory of radiation which proposes that all electromagnetic radiation consists of corpuscles or packets of energy, the energy content of any one packet being dependent upon the energy difference between two stationary energy states of an atom or molecule. Items 425 - 429 are experimental observations of electromagnetic radiation phenomena and are to be evaluated in accordance with the following key.

KEY

A. The observation supports or can best be explained by the wave theory of radiation.
B. The observation supports or can best be explained by the corpuscular theory of radiation.
C. The observation can be explained equally well by either theory.
D. The observation cannot be explained by either theory.

425. (6.20) When radiation passes through an aperture or past the edge of an obstacle, it always spreads to some extent into the region which is not directly exposed to the oncoming radiation.

426. (6.20) When a beam of light is incident on certain materials, such as cesium, electrons may be ejected from the material, the maximum speed of the ejected electrons being independent of the intensity of the incident light.

427. (6.20) When light from a single source is split into two beams by passing the light through two slits and then allowed to fall on a screen, a symmetrical pattern of evenly spaced light and dark bands or fringes may be observed.

428. (6.20) The velocity of light (and other electromagnetic radiation) in a vacuum has been accurately determined to be 2.99776×10^{10} centimeters per second.

429. (6.20) When a beam of light is incident (in a direction other than perpendicular) on a boundary between two media in which the velocity of light is different, the transmitted beam will have a direction different from that of the incident beam.

19. Heat

HEAT

For items 1 - 7 select from the key the most closely related term.

KEY

A. Conduction. **B.** Convection. **C.** Evaporation.
D. Condensation. **E.** Radiation.

1. Salt deposition in the hydrosphere.
(1.10)

2. Burning the hand from touching a hot steam radiator.
(1.10)

3. Not eliminated by having a vacuum space around a
(1.10) thermos bottle.

4. The chief way the atmosphere is heated by the *earth*.
(1.10)

5. The reduction of heat loss or gain by silvering the walls
(1.10) of a thermos bottle.

6. The sweating of cold water pipes especially in summer.
(1.10)

7. Water at 4°C. is found at the bottom of a lake in winter
(1.10) while water at 1°C. is at the top.

Items 8 - 10 involve the transfer of heat. For each item select from the key the *most* appropriate response.

KEY

A. Conduction. **B.** Radiation. **C.** Convection.
D. Evaporation. **E.** Condensation.

8. The use of hot water pipes buried in concrete to melt
(1.10) snow on airport runways.

9. The cause of land and sea breezes.
(1.10)

10. Ironing dry clothes.
(1.10)

Items 11 - 21 are related to heat transference. For each item select from the key the most appropriate term.

KEY

A. Conduction. **B.** Convection. **C.** Condensation.
D. Radiation. **E.** Reflection.

11. A room with the walls heated to 80°F. may feel com-
(1.10) fortable even though the temperature of the air in the room is only 50°F.

12. Coating the roof of a house with aluminum foil-like
(1.10) paint will make a house noticeably cooler in summer.

13. A method of transfer of heat directly from one molecule
(1.10) to another.

14. White clothing is cooler than black clothing for summer
(1.10) wear.

15. A method of heat transfer which requires differences
(1.10) in density within the medium.

16. Sweating of cold water pipes in summer.
(1.10)

17. Air movements associated with cumulo-nimbus clouds.
(1.10)

18. The collection of hot water at the top of a hot water
(1.10) tank.

19. Using an ice pack against the head.
(1.10)

20. Not prevented by having a vacuum space around a
(1.10) stoppered thermos bottle.

21. The reduction of heat loss or gain by silvering the walls
(1.10) of a thermos bottle.

22. Evaporation is a cooling process because
(1.10)

A. molecules of a vapor have less kinetic energy than those of the liquid.
B. during evaporation the molecules with the greater kinetic energy escape from the liquid.
C. water vapor conducts heat rapidly.
D. evaporation makes the air damp. **E.** none of these.

23. When a liquid is heated in an open vessel, its tem-
(1.10) perature rises until

A. it is completely vaporized.
B. its vapor pressure equals atmospheric pressure.
C. the latent heat is all absorbed.
D. the kindling temperature is reached.
E. the source of heat is removed.

24. An explanation of the fact that a rug feels warmer than
(1.10) the wooden floor on a cold morning, although both may be at the same temperature, would involve principally the phenomenon of

A. heat of fusion. **B.** heat of vaporization.
C. heat conduction. **D.** heat convection.
E. heat radiation.

25. Increasing the pressure on a block of ice at 0°C. will
(1.10)

A. raise the temperature.
B. lower the melting point of the ice.
C. cause no change in state.
D. decrease molecular activity.
E. raise the melting point of the ice.

26. Heat transfer by convection requires
(1.10)

A. differences in thermal conductivity.
B. temperatures above freezing. **C.** a change of state.
D. differences in density within the medium.
E. that the medium be in the form of a gas.

27. A regular type open fireplace heats a room largely by
(1.10)

A. conduction. **B.** convection. **C.** radiation.
D. sublimation.
E. some other means than given above.

28. The expansion of a solid on heating is due to
(1.10)

A. an increase in the size of the particles of the solid.
B. an increase in the agitation of the particles of the solid.
C. the addition of caloric to the solid.
D. application of the Kinetic-Molecular theory.
E. none of the above.

29. A gram of distilled water at 4°C.
(1.10)

A. will increase slightly in weight when heated to 10°C.
B. has a specific gravity of 62.4.
C. weighs less than a gram of water at 0°C.
D. will decrease in volume as its temperature is lowered.
E. will increase in volume when heated or cooled.

30. The formation of ice is accompanied by

(1.10) **A.** an absorption of heat. **B.** a temperature increase.
C. a decrease in volume. **D.** an evolution of heat.
E. a temperature decrease.

31. Ice is always placed in the top of an ice box because
(1.10)

- **A.** it is easier to get the ice into that part of the box.
- **B.** cold air is heavier per unit volume than warm air and sinks to the bottom of the box.
- **C.** the ice does not melt as rapidly in this part of the box.
- **D.** the ice contracts as it melts.
- **E.** the ice expands as it melts.

32. Water will keep cool in an unglazed earthenware jug
(1.10) because

- **A.** the jug absorbs cold air.
- **B.** water vapor from the atmosphere condenses on the jug.
- **C.** there is a large surface from which the water can evaporate.
- **D.** the jug cools the water.
- **E.** earthenware material is always cool.

33. The temperature inside a glass-enclosed, unheated
(1.10) greenhouse is always a few degrees higher than the temperature of the surrounding air. This is because

- **A.** growing plants radiate more energy than they receive from the sun.
- **B.** infra-red rays from the sun are transformed into ultra-violet rays.
- **C.** glass is a good conductor of heat.
- **D.** the critical angle of the roof is such that heat rays originating in the interior are reflected back.
- **E.** glass transmits a great deal of the radiation from the sun, but very little radiation from the plants and the soil.

34. If 40 calories of heat are required to vaporize one gram
(1.10) of a substance at 110°C., then it follows that

- **A.** 20 calories will be required to vaporize one gram of the substance at 55°C.
- **B.** 40 calories will be required to change one gram of the vapor to liquid.
- **C.** the temperature of the vapor must be higher than that of the liquid.
- **D.** 40 calories will vaporize one gram of the substance at 100°C.
- **E.** the same amount of heat will be given up when one gram of the vapor condenses at 110°C.

35. An iron stove used for heating a room *by radiation* is
(1.10) most efficient if

- **A.** its inner surface is highly polished.
- **B.** its inner surface is covered with aluminum paint.
- **C.** its outer surface is covered with aluminum paint.
- **D.** its outer surface is covered with soot.
- **E.** its outer surface is highly polished.

36. If the same amount of heat energy is applied without
(1.10) loss to two different substances of equal weight, their final temperature may be different. This is because

- **A.** they may differ in density.
- **B.** one may absorb more heat than the other.
- **C.** they may have different coefficients of expansion.
- **D.** one may be a better conductor of heat.
- **E.** one may have a higher specific heat.

37. Identical 1.00 gm. samples of coal are completely
(1.10) burned in closed containers. Chemical container 1 contains pure oxygen at a pressure of 1 atmosphere; 2 contains air at a pressure of 5 atmospheres. The initial temperatures are the same. What is the result?

- **A.** The maximum temperature in 2 is greater than in 1.
- **B.** The total amount of heat generated in 1 is less than that in 2.
- **C.** The total amount of heat generated in 1 is greater than that in 2.
- **D.** The total amount of heat generated in 1 is the same as that in 2.
- **E.** The amounts of heat evolved cannot be compared from the data furnished.

38. A hot breeze may seem distinctly cool to a bather who
(1.10) has just come from the water because

- **A.** water is a good conductor of heat.
- **B.** water has a high specific heat.
- **C.** water is more dense than air.
- **D.** the moisture in the air condenses on the bather's body and liberates heat.
- **E.** the evaporation of water from the bather's wet body absorbs heat.

39. Bodies of water help to moderate the climate because
(1.10)

- **A.** heat is given off when water evaporates.
- **B.** the specific heat of water is relatively large.
- **C.** the warmest water is always found at the surface.
- **D.** water is a good conductor of heat.
- **E.** water has a very high dielectric constant.

40. The principle of most direct significance in the opera-
(1.10) tion of mechanical refrigerators is that

- **A.** evaporation is a cooling process.
- **B.** it is impossible to convert heat wholly into work.
- **C.** cooling results when a vapor expands against the attractive forces which exist between the molecules.
- **D.** the volume occupied by a given mass of gas is inversely proportional to the pressure applied.
- **E.** none of the above applies to refrigerators.

41. In order that a liquid may serve as a good cooling
(1.10) medium in an automobile, it is most essential that it have a

A. low boiling point. **B.** high specific heat.
C. low specific gravity. **D.** high viscosity.
E. high coefficient of expansion.

42. Any liquid may be said to be boiling when
(1.10)

- **A.** its temperature is 100°C.
- **B.** the vapor pressure is 76 cm. of mercury.
- **C.** the vapor pressure is equal to the pressure over the liquid.
- **D.** molecules of vapor escape from the surface.
- **E.** the vapor pressure is less than the pressure over the liquid.

43. The heat absorbed by melting a block of ice
(1.10)

- **A.** can never be recovered.
- **B.** does not change the temperature of the melted water.
- **C.** depends upon the specific heat of ice.
- **D.** causes mechanical expansion.
- **E.** warms the surrounding container.

44. (1.10) The transfer of heat by currents through liquids and gases is known as

A. radiation. **B.** condensation. **C.** conduction.
D. osmosis. **E.** convection.

45. (1.10) Pyrex baking dishes are less likely to break than ordinary glass dishes when heat is applied because

A. pyrex glass has a greater tensile strength.
B. pyrex glass has a lower expansion coefficient.
C. pyrex glass dishes are always made with rounded corners.
D. ordinary glass always contains feldspar.
E. pyrex glass dishes are always thicker.

46. (1.10) The formation of ice is accompanied by

A. an absorption of heat. **B.** a temperature increase.
C. a decrease in volume. **D.** an evolution of heat.
E. a temperature decrease.

47. (1.10) The actual transfer of heat from one object to another is accomplished by means of

A. conduction only. **B.** radiation only.
C. conduction and convection.
D. radiation and convection.
E. conduction and radiation.

48. (1.10) Since 540 calories are required to vaporize 1 gm. of water at 212°F., it follows that

A. 270 calories would vaporize 1 gm. at 106°F.
B. for every 540 calories added, the temperature of the water rises 1°F.
C. the weight of the vapor is greater than 1 gm. for every gm. of water vaporized.
D. 540 calories are released when 1 gm. of vapor condenses at 212°F.
E. adding 540 calories successively, increases the vapor pressure over the open container.

49. (1.10) When an electric current flows through a resistance, the energy is expended as

A. chemical energy. **B.** amperes. **C.** volts.
D. sound. **E.** heat.

50. (1.10) As an aid in keeping buildings cool in summer, dark colored window shades have been replaced by light colored shades. The best explanation of this is that the light colored shades

A. are more pleasing to the eye.
B. absorb a greater portion of the ordinary light rays.
C. reflect a greater portion of the ordinary light rays.
D. transmit a greater portion of the ordinary light rays.
E. none of the above explanations apply.

51. (1.10) During the time latent heat is involved in a change of state,

A. the temperature will not change.
B. the substance always expands.
C. a chemical change occurs.
D. molecular activity is constant.
E. kinetic energy changes to potential.

52. (1.10) Which one of these is *not* true of the absolute scale of temperature?

A. The size of a degree on the absolute scale is the same as on the centigrade.
B. The lowest point on the absolute scale represents the minimum temperature.
C. There are 273 degree spaces between the freezing and boiling point for water on the absolute scale.
D. Maximum temperatures possible on the scale have not been established.
E. The temperature at which molecular motion ceases is the same for all substances.

53. (1.10) Ordinary winds provide a good example of heat transfer by

A. convection. **B.** conduction. **C.** radiation.
D. precipitation. **E.** rotation.

54. (1.10) Sunlight streaming through the windows of a closed automobile warms the interior of the automobile more than if the windows were left open. An explanation of this depends most upon the principle that

A. glass is completely permeable to infra-red rays.
B. glass is more transparent to some wave lengths than others.
C. glass is a poor conductor of all radiations.
D. black objects radiate heat more readily than lighter objects.
E. glass does not transmit ultra-violet radiations.

55. (1.10) The freezing point of water is stated to be 0°C. under standard conditions. The truth of the statement follows from

A. the kinetic theory.
B. the definition of the heat of fusion.
C. the definition of the Centigrade scale.
D. the absence of heat energy in water in the solid state.
E. properties inherent in the water.

56. (1.10) Storm windows largely reduce heat loss by affecting that method of heat transfer termed

A. conduction. **B.** convection. **C.** evaporation.
D. radiation. **E.** reflection.

57. (1.10) A liquid always boils when

A. the pressure of the saturated vapor equals *standard* atmospheric pressure.
B. the liquid reaches a temperature of 100 degrees C.
C. the liquid evaporates freely under standard conditions of pressure.
D. the pressure of its saturated vapor equals the atmospheric pressure.
E. its vapor pressure equals 1 gram/sq. cm.

58. (1.10) Moist air acts as a blanket to lessen decreases in ground temperature because

A. the cold from outer space cannot penetrate moist air.
B. winds which could blow the heat elsewhere are seldom associated with moist air.
C. moist air acts as a barrier to retard the advance of cold air masses into an area.
D. moist air is not transparent to heat radiation from the earth.
E. convection currents do not occur in moist air.

59. (1.10) The term heat is often used loosely. The popular statement in which it is used incorrectly is:

A. The radiator gives off a great amount of heat.
B. He turned off the heat in the radiator.
C. A student heated a test tube.
D. The engine is heating up.
E. The heat of the water in the pool was 68 degrees F.

60. (1.10) During the time latent heat is involved in a change of state,

A. molecular activity of the substance is constant.
B. the substance will always expand.
C. the kinetic energy of the substance will change to potential.
D. the temperature will not change.
E. a chemical change occurs.

61. (1.10) If pressure is exerted on

A. steam it will make the steam cooler.
B. ice it will lower the freezing point.
C. water it will make the density drop from 1 to approximately .8 grams per cc.
D. ice it will make the ice expand.
E. water it will lower the boiling point.

62. (1.10) Meteors are visible because

A. they have the composition of ordinary fuels.
B. of an optical illusion.
C. they are fragments of hot bodies like stars.
D. of high temperature developed by air friction.
E. of reflected sunlight from the surface of the moon.

63. (1.10) On a mountain top, the temperature of boiling water may be 187°F. instead of 212°. The most effective way to raise the temperature for cooking purposes would be to

A. add several spoonfuls of salt.
B. use a pan with a smaller area of exposed water surface.
C. reduce the vapor pressure over the liquid.
D. turn up the flame to increase the rate of boiling.
E. cover the pan tightly with a sealed safety lid.

64. (1.10) A foreman wishes to know the continuous daily temperature within a large pile of coal. The type of temperature measuring device best suited for this would be

A. a mercury thermometer. **B.** a thermocouple.
C. an optical pyrometer.
D. a bimetallic strip thermometer.
E. an air thermometer.

65. (1.10) If sufficient heat is removed from 1 gm. of water at 100°C. to cool it to 0°C., it necessarily follows that

A. its volume will be unchanged. **B.** it will freeze.
C. its density will be the least at 4°C.
D. it will decrease in volume and then increase.
E. it will reach its greatest density at 0°C.

66. (1.10) If you are sitting in a room in a house warmed by means of a heating system involving the circulation of hot water through radiators, you are being warmed by

A. conduction alone. **B.** convection alone.
C. radiation alone. **D.** convection and radiation.
E. conduction, convection, and radiation.

67. (1.10) Suppose we have a pitcher of ice in ice-water, any part of which we may use to cool a beverage. Would 200 g. of ice or 200 g. of ice-water be more effective in cooling a beverage?

A. Ice, because it is colder.
B. Ice-water, because its specific heat is greater.
C. Ice, because its specific heat is greater.
D. Ice-water, because it is heavier.
E. Ice, because of its heat of fusion.

68. (1.10) Regions near large bodies of water are much less subject to wide variations of temperature than inland regions because of the

A. low heat capacity of water.
B. high heat capacity of water.
C. low heat conductivity of water.
D. high heat conductivity of water.

69. (1.10) A vessel is filled with a known mass of water and contains a thermometer and a paddle wheel rotated by force transferred by a rope and pulley system from a falling object of known mass. This apparatus is useful in determining the

A. specific heat of water.
B. relation between $\frac{1}{2} mv^2$ and the absolute temperature.
C. coefficient of thermal conductivity, K.
D. mechanical equivalent of heat, J.
E. efficiency of a heat engine.

True or False.

70. (1.10) ( ) The temperature coefficient of most pure metals is approximately .004.

71. (1.10) Most substances expand more or less uniformly when heated. Exceptions to the rule serve important purposes in the physical world. Which one of these is an exception to the rule?

A. Wood. **B.** Air. **C.** Copper. **D.** Granite.
E. Water.

72. (1.10) Which one of these is *not* true of the absolute scale of temperature?

A. The size of a degree on the absolute scale is the same as on the centigrade.
B. The lowest point on the absolute scale represents the minimum temperature possible for any substance.
C. There are 274 degree spaces between the freezing and boiling point for water on the absolute scale.
D. Maximum temperatures possible on the scale have not been established.
E. The temperature at which molecular motion ceases is the same for all substances.

73. (1.10) Which one of the following is a correct definition of specific heat?

A. The number of calories necessary to change the state of one gram of the substance.
B. The number of calories emitted by the complete oxidation of one gram of the substance.
C. The number of calories necessary to raise the temperature of one gram of the substance from 0°C. to the kindling temperature.
D. The number of calories necessary to change the temperature of one gram of the substance one degree Centigrade.
E. None of the above is a correct definition of specific heat.

74. (1.10) In the laboratory determination of the specific heat of a metal it is necessary to take into consideration all of the following *except* the

A. weight and specific heat of water in the liquid state.
B. weight and specific heat of water in the solid state.
C. weight and specific heat of the calorimeter cup and stirrer.
D. temperature of the water.
E. weight of the metal sample.

The following key applies to questions 75 - 78.

- **A.** Statement 1 is greater in quantity or magnitude than statement 2.
- **B.** Statement 2 is greater in quantity or magnitude than statement 1.
- **C.** Both statements are quantitatively equal.
- **D.** No definite decision can be made from the information given.

	Statement 1	*Statement 2*
75. (1.10)	The speed of a given chemical reaction at 10°C.	The speed of the same chemical reaction at 20°C.
76. (1.22a)	The temperature of a substance in which the average molecular speed is 100 "units."	The temperature of the same substance when the average molecular speed is less than 100 "units."
77. (1.10)	The immediate effect on body heat production of eating 500 grams of carbohydrates.	The immediate effect on body heat production of eating 500 grams of fat.
78. (4.20)	The tolerance of a man to heat in an environment of 100% relative humidity, at 90°F.	The tolerance of the same man to heat in an environment of 10% relative humidity, at 90°F.

After the item number on the answer sheet, blacken the *one* lettered space indicating the term at the right to which the item *most* correctly refers.

79. (1.10) The quantity of heat needed to melt one gram of a substance at its melting point without change in temperature.

80. (1.10) The process of heat transfer where heat energy passes through a substance from molecule to molecule.

81. (1.10) The process of transferring heat which is employed in a warm air heating system.

82. (1.10) The quantity of heat necessary to change the temperature of unit mass of a substance one degree in temperature.

- **A.** Convection.
- **B.** Specific heat.
- **C.** Heat of fusion.
- **D.** Heat of evaporation.
- **E.** Conduction.

After each item number on the answer sheet, blacken space

A if the item on the left is the greater.
B if the item on the right is the greater.
C if the item on the left and right are of the same magnitude.

83. (1.10)	Time required to boil an egg on top of Pike's Peak.	....	Time required to boil an egg under pressure in a pressure cooker.
84. (1.10)	Amount of heat required to melt one pound of ice.	....	Amount of heat required to turn one pound of water at 100°C. into steam.
85. (1.10)	Kinetic energy of pendulum at lowest point of swing.	....	Potential energy of pendulum at highest point of swing.
86. (1.10)	Length of long steel bridge in winter.	....	Length of same bridge in summer.
87. (1.10)	Density of water at 0°C.	....	Density of water at 4°C.

88. (1.10) That the ratio of the work in joules to the heat in calories is constant is

- **A.** Coulomb's Law.
- **B.** a consequence of Charles' Law.
- **C.** the first law of Thermodynamics.
- **D.** an isothermal change.
- **E.** illustrated in the operation of a thermocouple.

89. (1.10) The specific heat of common substances is

- **A.** the same.
- **B.** the intensity of the heat of a substance.
- **C.** the number of calories present in a substance.
- **D.** always a small whole number.
- **E.** generally less than 1 calorie/gram/°C.

90. (1.10) Room temperature is often quoted as 20 degrees on the

A. Absolute scale. **B.** Kelvin scale.
C. Centigrade scale. **D.** Angstrom scale.
E. Fahrenheit scale.

91. (1.10) The first law of thermodynamics expresses the relationship between

A. joules and calories. **B.** coulombs and force.
C. calories and temperature. **D.** amperes and watts.
E. ohms and calories.

92. (1.10) Which of the following is a device for measuring temperature?

A. Optical pyrometer. **B.** Photoelectric cell.
C. Calorimeter. **D.** Radiometer. **E.** Electroscope.

93. (1.10) All of these scales are related in some way *except*

A. Vernier. **B.** Absolute. **C.** Kelvin.
D. Centigrade. **E.** Fahrenheit.

94. (1.10) We picture the zero on the absolute scale as the temperature at which

- **A.** the molecular kinetic energy is zero.
- **B.** the volume of the substance is zero.
- **C.** the pressure is 1/273 of its value at 0°C.
- **D.** the Centigrade and Fahrenheit scales coincide.
- **E.** the pressure has changed by 1/273 of its value at 100°C.

95. (1.10) A liquid boils whenever

- **A.** the latent heat of vaporization has all been absorbed.
- **B.** its vapor pressure reaches the pressure on its surface.
- **C.** bubbles form within it.
- **D.** it is heated to a certain temperature.
- **E.** its temperature reaches 100°C.

96. (1.10) On the absolute scale the normal boiling point of water is

A. —100°. **B.** —273°. **C.** 100°. **D.** 312°.
E. 373°.

97. (1.10) Heat is transferred along a metal rod by the process called

A. convection. **B.** induction. **C.** deduction.
D. effusion. **E.** conduction.

98. (1.10) Mercury is used in thermometers largely because

- **A.** of its high density.
- **B.** it is more readily purified than other liquids.

C. it has a fairly large coefficient of expansion.
D. it has the same coefficient of expansion as glass.
E. it is one of the cheaper metals.

99. (1.10) The specific heat of a body is

A. the amount of heat energy required to raise its temperature one degree.
B. the ratio of its heat capacity to that of an equal mass of water.
C. dependent upon the temperature scale we are using.
E. the same thing as its latent heat.

100. (1.10) Ordinary room temperature is about 20° on the

A. Absolute scale. **B.** Centigrade scale.
C. Reamur scale. **D.** Fahrenheit scale.

101. (1.10) A British thermal unit is a unit of

A. quantity of heat. **B.** absolute temperature.
C. temperature difference. **D.** expansion.
E. pressure change.

102. (1.10) The critical temperature of a gas is that temperature

A. above which a gas is always in the vapor phase.
B. below which a gas cannot be liquefied.
C. corresponding to the triple point of the substance.
D. at which the gas vaporizes.
E. at which the gas solidifies.

103. (1.10) Heat capacity is a measure of

A. the amount of heat required to raise the temperature of a certain amount of substance a certain amount.
B. the change in temperature of a substance caused by adding one calorie of heat.
C. the maximum temperature to which you can heat a substance before it decomposes.
D. the temperature a substance will assume if it is placed in water of a certain temperature.
E. the amount of substance which contains one calorie of heat.

104. (1.10) Which of the following is correct?

A. A one degree centigrade change in temperature is the same as a one degree Fahrenheit change.
B. Zero degrees Fahrenheit is about 15 degrees Centigrade.
C. The centigrade thermometer is based on the freezing and boiling temperatures of water.
D. A desirable liquid to use in an ordinary thermometer should not expand or contract as temperature is raised or lowered.
E. About −27 degrees centigrade is the coldest possible temperature.

105. (1.22a) Which of the following changes would *not* increase the rate of heat passage through a barrier?

A. Increase the area. **B.** Decrease the thickness.
C. Increase the temperature difference between the two sides.
D. Allow the heat to pass for a longer period of time.
E. Replace a non-metallic barrier with a metallic barrier.

For items 106 and 107 evaluate the statements according to the key:

KEY

A. An increase of the first will produce an increase in the second.
B. An increase of the first will produce a decrease in the second.
C. One will remain practically constant regardless of how the other changes.

106. (1.22a) Temperature of a liquid—Rate of evaporation.

107. (1.22a) Amount of heat being applied to the liquid—Temperature of a boiling liquid.

108. (1.22a) A drinking glass can withstand sudden changes in temperature if the glass

A. is thick. **B.** is thin.
C. has a small specific heat.
D. has a high coefficient of expansion.
E. is a poor conductor of heat.

109. (1.22a) A housewife was boiling potatoes at a steady rate in an open pan. Turning up the flame to the highest point would *not*

A. affect the fuel consumption.
B. lower the rate of evaporation.
C. raise the temperature of the water.
D. affect the cooking time if the pan were tightly covered.
E. affect the temperature of the kitchen.

110. (1.22a) The amount of heat passing through the bottom of a coffee pot on a gas stove is *independent* of

A. the temperature gradient in the bottom of the pot.
B. the thickness of the material in the bottom of the pot.
C. the kind of material of which the pot is made.
D. the area of the bottom of the pot.
E. the amount of coffee in the pot.

111. (1.22a) The distribution of heat in hot-air systems depends upon the

A. decrease of air density with increase in temperature.
B. rapid transfer of heat from heated molecules to adjoining molecules.
C. absence of water vapor.
D. transfer of energy in the form of waves.
E. conduction of heat by the air.

112. (1.24) Indicate experimental or observational study giving best support for statement. "Heat is a form of energy and not a substance or fluid."

A. conduction of heat.
B. a liquid can be warmed by stirring.
C. conservation of heat.
D. heats of melting and evaporation.
E. heat flows from a hot body to a colder one.

113. (1.30) "The quantity of heat required to increase the temperature of different substances by the same number of degrees is directly proportional to the quantity of matter in each." This statement is in contradiction to the currently accepted concept of

A. latent heat. **B.** friction as a source of heat.
C. specific heat. **D.** caloric. **E.** critical temperature.

114. The fact that water, when being heated from 2°C. to
(1.30) 6°C., first contracts and then expands can be satisfactorily explained by

A. the Caloric Theory of heat.
B. the Kinetic Theory of heat.
C. either of the above theories.
D. neither of the above theories.

115. Beverages too hot to drink are sometimes cooled by
(1.30) stirring. Which of the following would serve to *defeat* the intended purpose?

A. Mechanical equivalent of heat. **B.** Conduction.
C. Convection. **D.** Radiation. **E.** Calorimetry.

116. Which of the following would be *most* apt to undergo
(1.30) the *least* temperature change over a period of a few hours?

A. A glass of water containing melting ice.
B. A pan of water covered with a tight fitting lid and placed on a heating unit.
C. An open container of gasoline with air of constant temperature bubbling through it.
D. A melting ice cube placed in the freezing unit of a fast-freeze food locker.
E. The water at the bottom of a small pond while the surface is freezing over.

Item 117 deleted.

118. The concept that would be most helpful in explaining
(1.30) the effect of adding a solute at the boiling point of a solution is that of

A. specific heat. **B.** vapor pressure.
C. adiabatic change. **D.** kinetic energy.
E. heat of vaporization.

119. The specific heat of copper is 0.093. This characteristic
(1.30) makes it

A. a substance of low expansion.
B. inactive chemically.
C. a good insulation material.
D. a poor conductor of heat.
E. good for making cooking utensils.

120. The freezing point on the Fahrenheit scale is 32°,
(1.30) while on the Centigrade scale it is 0°. The boiling point is 212°F., while on the C. scale it is 100°. By which one of the following formulas could a temperature reading of 70°F. be converted to its equivalent C. reading?

A. C. = 5/9 (F. — 32). **B.** F. = 9/5 C. — 32.
C. C. = 9/5 F. + 32. **D.** F. = 5/9 C. — 32.
E. C. = 5/9 F. — 32.

121. The coefficient of expansion (increase in length per unit
(1.30) length or volume per unit volume per degree change in temperature)

A. of metals is much larger than for liquids.
B. of liquids is much larger than for gases.
C. is the same for all gases.
D. differs very little from one metal to another metal.
E. is greater when Fahrenheit rather than Centigrade degrees are used.

122. When air is let out of a tire, the temperature of the
(1.30) air is reduced because

A. the pressure of a gas is inversely proportional to the absolute temperature.
B. expansion increases the degree of molecular freedom.
C. work is done at the expense of heat energy.
D. air is a good conductor of heat.
E. convection takes place.

123. Prior to 1760 physicists assumed that—"the quantities
(1.30) of heat required to increase the heat of different bodies by the same number of degrees were directly in proportion to the quantity of matter in each." This assumption is modified by the modern concept of

A. latent heat. **B.** friction as a source of heat.
C. specific heat. **D.** caloric. **E.** critical temperature.

Items 124 and 125 refer to this situation: Two like pans, one containing pure water, the other a fudge mixture, are heated at equal rates (assume that the specific heat of both is the same).

124. Comparison of the two pans will show that the
(1.10)

A. pans will boil at about the same time.
B. pan containing water will boil first.
C. pan containing fudge will boil first.

125. Because
(1.30)

A. the fudge mixture contains some substance with a lower boiling point.
B. under like conditions all liquids boil at the same temperature.
C. the fudge mixture is composed partly of substances dissolved in water.
D. adding a solute to a solvent lowers the boiling temperature.
E. water boils more quickly because it evaporates more quickly and evaporation is a cooling process.

Below are six statements. Indicate which category of the key best applies to each statement by circling the appropriate letter at the left.

KEY

C. applies only to the caloric theory of heat.
K. applies only to the kinetic theory of heat.
B. applies to both theories.
N. applies to neither theory.

126. C K B N Heat is self-repulsive and forms an atmos-
(1.30) phere around the atoms of a gas.

127. C K B N Heat is the result of friction between the
(1.30) atoms of molecules.

128. C K B N Heat will flow by itself from a hot body
(1.30) to a cold body, but not the reverse.

129. C K B N Heat consists essentially of particles which
(1.30) are smaller than the atoms and can penetrate their interior

130. C K B N Heat is essentially the motion of particles
(1.30) of matter.

131. C K B N As a mass of gas expands, the heat is dis-
(1.30) tributed through a larger volume, thus reducing the temperature.

132. A silver spoon put in a glass before adding boiling
(1.30) water sometimes prevents the glass from cracking because

A. it has a high coefficient of expansion.
B. it allows steam bubbles to collect on it.

C. the specific heat of silver is very high.
D. the specific gravity of silver is greater than that of glass.
E. it reduces the temperature of the water.

133. (1.30) One important principle involved in the construction of the thermos bottle is that

A. glass is a good conductor of heat.
B. glass has a small coefficient of expansion.
C. a vacuum is a better conductor of heat than air.
D. a vacuum is a poorer conductor of heat than air.
E. a vacuum prevents heat radiation.

134. (1.30) Local health requirements in a certain place ask that all drinking water be boiled for five minutes. If a supply of water, being heated in an open vessel, is brought to the boiling point, for the ensuing five minutes the minimum heat supply necessary to continue the boiling

A. is certainly zero.
B. is merely that needed to balance cooling by evaporation.
C. is merely that needed to balance the radiation loss.
D. is merely that needed to balance the conduction loss.
E. must not only provide for radiation and conduction losses, but must also provide against cooling by evaporation.

135. (1.30) If one body *1* is at a higher temperature than another body *2*.

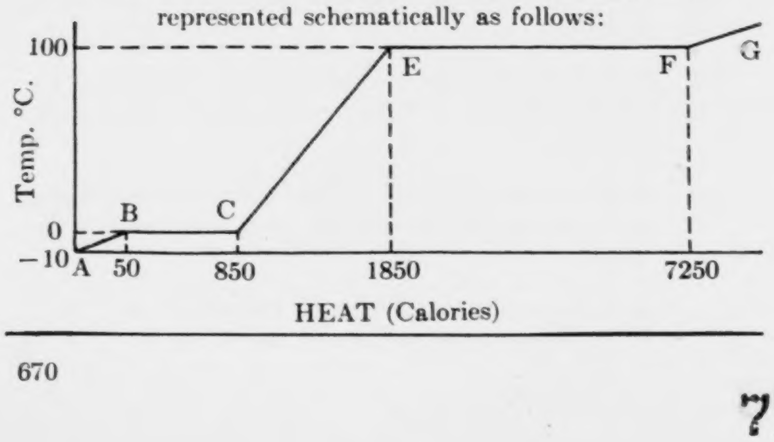
A. *1* must contain more heat energy than 2.
B. the average kinetic energy per molecule of *1* is greater than that of 2.
C. the total molecular kinetic energy of *1* is greater than that of 2.
D. *2* has a greater heat capacity than has *1*.

136. (1.30) According to accepted theory, the heat content of a substance

A. is equal to the sum of the potential energies of all its molecules.
B. is equal to the sum of the kinetic energies of all its molecules.
C. is equal to the sum of the kinetic and potential energies of all its molecules.
D. is proportional to the average kinetic energy of its molecules.
E. is equal to the average kinetic energy of its molecules.

For items 137 - 141 select from the key that portion of the curve in the diagram which furnishes the desired information.

The relationships between the addition or removal of heat and the consequent changes in the temperature and physical state of 10 grams of water may be represented schematically as follows:



KEY

A. A B. **B.** B C. **C.** C E. **D.** E F.
E. F G.

137. (2.10) The heat of fusion.

138. (2.10) The heat of vaporization.

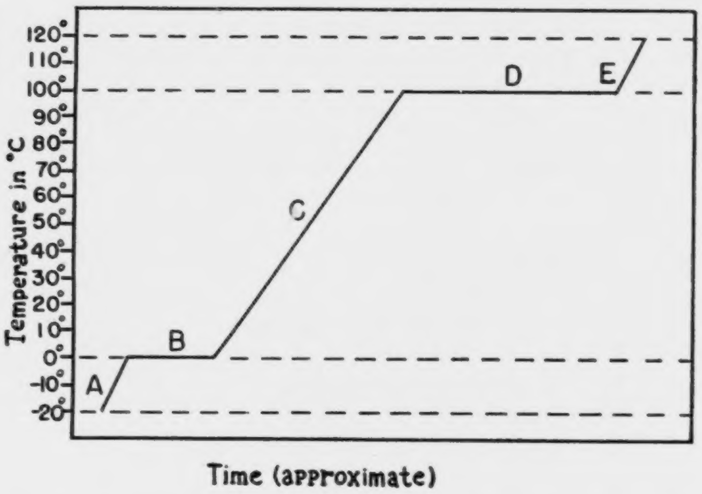
139. (2.10) The specific heat equals 1 cal./gm./°C.

140. (2.10) The volume change is the greatest.

141. (2.10) The vapor pressure and atmospheric pressure are approximately equal.

For items 142 - 145, consider that heat is uniformly applied to 10 gms. of H_2O initially in the form of ice at —20°C. Use any of the following data which may be necessary.

Specific heat of water: 1
Specific heat of ice: .5
Specific heat of steam: .47
Heat of fusion: 80 calories/gm.
Heat of vaporization: 540 calories/gm.



Items 142 - 145. Select from the key the lettered section of the graph for which the item would be true.

KEY

A. A. **B.** B. **C.** C. **D.** D. **E.** E.

142. (2.10) The addition of salt would lower this line on the temperature scale.

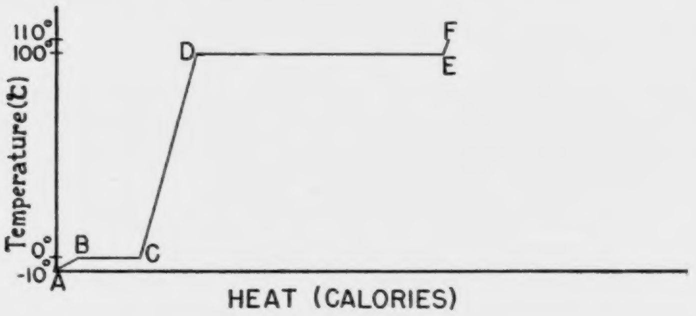
143. (2.10) The addition of one calorie of heat would increase the temperature a greater amount along this line than along any other.

144. (2.10) Along this line the pressure must exceed atmospheric pressure.

145. (2.10) A total of 94 calories of heat would be needed for the whole 10 gm. along this line.

The following graph represents schematically the relationship between temperature and quantity of heat when one gram of ice initially at a temperature of —10°C. is heated until the temperature of the system reaches 120°C.

Items 146 - 149 are to be evaluated by means of the following graph and in accordance with the key.



KEY

A. AB. B. BC. C. CD. D. DE. E. EF.

146. (2.10) That part of the graph which represents the heat of fusion.

147. (2.10) That part of the graph which represents the heat of vaporization.

148. (2.10) That part of the graph which represents the state of matter to which may be applied the law $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$.

149. (2.10) That part of the graph which represents the temperature range during which the volume will be the smallest (assuming no change in pressure).

150. (2.10) The compression of a gas is adiabatic if

- **A.** the temperature is lowered during compression.
- **B.** heat is removed as fast as it is formed.
- **C.** the temperature is held constant.
- **D.** no heat is removed or added from an outside source.
- **E.** heat is added from an outside source.

151. (2.10) On a Fahrenheit thermometer, the temperature half-way between that of melting ice and boiling water is

A. 50°. **B.** 68°. **C.** 90°. **D.** 106°. **E.** 122°.

152. (2.10) If the specific heat of aluminum is 0.22 calories/gram/°C., the number of calories required to increase the temperature of 10 grams of aluminum from 15°C. to 20°C. is

A. 5. **B.** 11. **C.** 1.1. **D.** 50. **E.** 22.

153. (2.10) The temperature in a medium refers to

- **A.** the quantity of molecules present.
- **B.** the total potential energy of the molecules.
- **C.** the average kinetic energy of the molecules.
- **D.** the total caloric content of the individual molecules.
- **E.** the average potential energy of the molecules.

154. (2.10) If, without loss of heat to the surroundings, 100 grams of aluminum of specific heat, 0.2 at 100°C. is dropped into 100 grams of water at 10°C., the final temperature, in degrees Centigrade will be

A. 55. **B.** 85. **C.** 45. **D.** 25. **E.** 15.

155. (2.10) A room thermometer graduated in the Fahrenheit scale reads 40 degrees. Outside the window a Centigrade thermometer reads 18 degrees. The temperature difference in Fahrenheit degrees between the inside and outside is

A. 22. **B.** 12. **C.** 2. **D.** 0.
E. some quantity other than the above four.

156. (2.10) Using the appropriate formula, what is the Centigrade equivalent of 23°F?

A. −5°C. **B.** 30 5/9°C. **C.** 73 2/5°C.
D. 99°C. **E.** −19 2/9°C.

157. (2.10) If a number of substances were heated to various temperatures, the one with the greatest heat energy would be the

- **A.** substance with the greatest mass.
- **B.** one with the highest temperature.
- **C.** best conductor of heat.
- **D.** one which contains the most calories.
- **E.** one which cools off at the slowest rate.

158. (2.10) A pilot takes the temperature in the cockpit of his plane and finds it to be 50 degrees *Fahrenheit.* He reads the outside air temperature on the *Centigrade* scale and finds it to be 10 degrees *Centigrade.* The temperature difference in degrees *Fahrenheit* between the inside and outside is

A. 75.6 **B.** 23.3 **C.** 37.6 **D.** 12.3
E. There is no difference.

159. (2.10) A 100 g copper calorimeter (use .090 as the specific heat of copper) at a temperature of 15.0 degrees C contains 200 g of water at 15.0 degrees C. A 300 g mass of aluminum at a temperature of 100 degrees C is plunged into the water. The temperature of the water rises to 34.7 degrees C. The specific heat of the aluminum is

A. .210. **B.** .361. **C.** .613. **D.** .501. **E.** .841.

160. (2.10) 81 calories is the amount of heat necessary to

- **A.** raise the temperature of 1 gram of ice from −1 degree C to 0 degrees C. (The ice is not melted in the process.)
- **B.** raise the temperature of 80 grams of water 1 degree C.
- **C.** raise the temperature of 1 gram of water 1 degree C.
- **D.** raise the temperature of 1 gram of ice from 0 degrees C to water at 1 degree C.
- **E.** melt 81 grams of ice.

161. (2.10) One could take a bath comfortably in water at a temperature of

A. 303° absolute. **B.** 75°C. **C.** 95° absolute.
D. 150°F. **E.** 250 degrees C. above absolute zero.

162. (2.10) If we heat 20 grams of water 5° Centigrade, we know the heat absorption will be

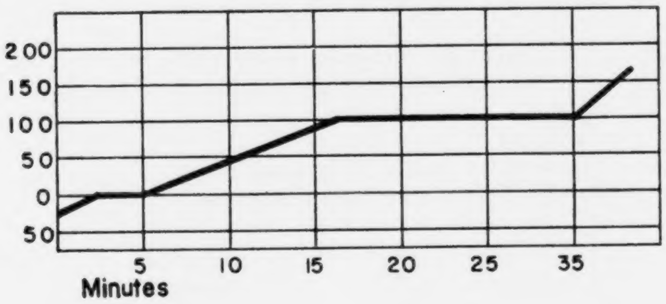
A. 20 calories. **B.** 50 calories. **C.** 75 calories.
D. 100 calories. **E.** 125 calories.

163. (2.10) A gram of ice at −100°C. is heated until it becomes steam at a temperature of 200°C. The greatest amount of heat is absorbed when the

- **A.** temperature of the ice is raised from −100°C. to 0°C.
- **B.** ice changes to water at 0°C.
- **C.** temperature of the water is raised from 0°C. to 100°C.
- **D.** water changes to steam at 100°C.
- **E.** temperature of the steam is raised from 100°C. to 200°C.

Items 164 - 167.

The graph given below shows the variation in temperature which results from heating a quantity of ice until it changes first to water and then to steam.



164. (2.10) The temperature of the ice at the start of the experiment was evidently about

A. 5°C. **B.** 0°C. **C.** –5°C. **D.** –10°C.
E. –30°C.

165. (2.10) While the ice was melting the temperature evidently

A. dropped. **B.** remained constant.
C. increased slowly. **D.** doubled. **E.** varied.

166. (2.10) Above 0°C. and up to 100°C., the temperature of the water

A. increased at a constant rate.
B. increased at a variable rate.
C. increased more rapidly than before the ice began to melt.
D. increased more rapidly than after the water had changed to steam.
E. increased while the water changed to steam.

167. (2.30) It can be predicted from the diagram that the steam would reach a temperature of 200°C. in about________ more minutes from end of dark line.

A. one. **B.** three. **C.** five. **D.** fifteen.
E. twenty.

168. (2.10) The latent heat of fusion of ice is 80 calories per gram. 100 grams of ice at 0°C. are melted to water at 0°C. The heat absorbed by the ice in changing to water is

A. 80 calories. **B.** 100 calories. **C.** 800 calories.
D. 8,000 calories. **E.** none of these.

169. (1.10) The heat energy referred to in the preceding exercise becomes

A. kinetic energy of the molecules.
B. energy of combination of the molecules.
C. the heat of reaction of the molecules.
D. the potential energy of the molecules.
E. the potential and kinetic energy of the molecules.

170. (2.10) Which one of the following is the lowest temperature in the list?

A. 140°F. **B.** 75°C. **C.** 312° absolute.
D. 250°C. above absolute zero.
E. 95°C. below the boiling point of water.

171. (2.10) If heat were applied to a piece of ice at –5°C. until the final temperature were 105°C., in which one of the following temperature intervals would the most heat be applied?

A. –5°C. to 5°C. **B.** 5°C. to 15°C.
C. 45°C. to 55°C. **D.** 95°C. to 105°C.
E. All of the above interval changes require the same amount of heat.

172. (2.10) If equal weights of ice at 0°C. and water at 100°C. are mixed without heat loss or gain from the surroundings, the resulting temperature would be

A. somewhere between 51 and 99 degrees C.
B. somewhere between 1 and 49 degrees C.
C. exactly 50 degrees C. **D.** zero degrees C.
E. variable since the ice would float in the water.

173. (2.10) The coefficient of linear expansion of steel is .000012 per degree C. The volume of a sphere is $4/3\pi r^3$. If a student needed the *volume* coefficient of expansion for steel to use in a problem, he would use

A. $(.00012)^3$ **B.** 4/3 times .000012.
C. 3 times .000012.
D. the same coefficient as in the linear case.
E. a handbook to find the volume coefficient because it bears no relation to the linear coefficient.

174. (2.10) If the temperature of a fixed volume of gas is 0°C., the temperature to which the gas must be raised to approximately double the pressure is

A. 2°C. **B.** 100°C. **C.** 273°C. **D.** 273°A.
E. none of the above.

175. (2.10) 600 gm. of Substance 1 at 50°C. was mixed with 600 gm. of Substance 2 at 30°C. in a calorimeter. The equilibrium temperature was 43°C. Disregarding any heat change in the calorimeter, the specific heat of Substance 1 can be calculated to be

A. equal to that of Substance 2.
B. higher than that of Substance 2.
C. lower than that of Substance 2.
D. a comparison of the specific heats cannot be made from this data.

176. (2.10) Of these scales on which one would a 10 degree change be actually smaller than a 10 degree change on any of the others?

A. Absolute scale. **B.** Kelvin scale.
C. Fahrenheit scale. **D.** Centigrade scale.
E. The same on all of the above.

177. (2.10) The heat required to raise the temperature of 50 lbs. of water from 40°F to 80°F is

A. 50 B.T.U.'s. **B.** 40 B.T.U.'s.
C. 2000 B.T.U.'s. **D.** 10 B.T.U.'s.
E. none of these.

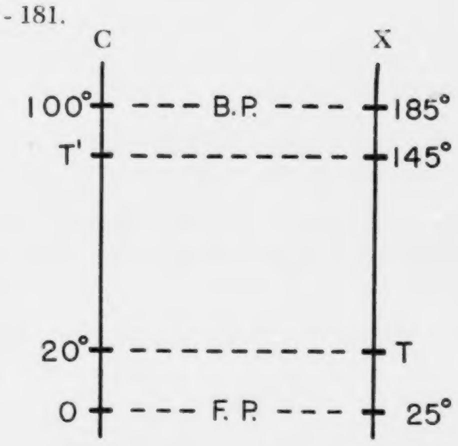
178. (2.10) If to 10 grams of ice at 0°C. we add 1000 calories, the result will be

A. water at 99.5°C. **B.** ice at 0°C.
C. a mixture of ice and water.
D. water at 20°C. **E.** steam.

179. (2.10) If 30 calories change the temperature of 50 grams of a substance from 20°C. to 40°C. the specific heat of the substance is

A. 0.01. **B.** 0.03. **C.** 1. **D.** 0.3. **E.** 0.1.

Items 180 - 181.



C represents a Centigrade thermometer and X a thermometer on which the boiling point of water at 76 cms. pressure has been marked 185° and the freezing point 25°.

180. (2.10) When the Centigrade thermometer reads 20° the corresponding reading T on the X thermometer is

A. 32°. **B.** 37°. **C.** 57°. **D.** 67°. **E.** 52°.

181. (2.10) When the X thermometer reads 145°, the corresponding reading T on the Centigrade thermometer is

A. 50°. **B.** 64°. **C.** 72°. **D.** 75°. **E.** 90°.

182. (2.10) A carnot engine operates between the temperatures of 300°C. and 100°C. The efficiency of the engine is

A. 30%. **B.** 35%. **C.** 50%. **D.** 67%. **E.** 82.5%.

183. (2.10) What Fahrenheit temperature is equivalent to 373° Kelvin?

A. 32° Fahrenheit. **B.** 122° Fahrenheit.
C. 212° Fahrenheit. **D.** 0° Fahrenheit.
E. 273° Fahrenheit.

184. (2.20) If two identical vacuum bottles, one filled with coffee at 0°C. and the other with coffee at 100°C., are placed in a room at normal temperature (about 22°C.), the cold coffee will remain cold much longer than the hot coffee will remain hot. This can be explained by stating that

A. the vacuum space allows heat to penetrate from the inside to the outside but not from the outside to the inside.
B. the rate of heat transfer depends on the amount of air remaining in the vacuum space.
C. heat is transferred much more rapidly at high temperatures than at low temperature.
D. the rate of heat transfer depends primarily on the difference in temperature between the inside and the outside.
E. the statement is incorrect. In a vacuum bottle, hot coffee remains hot and cold coffee remains cold for an infinite period of time.

185. (2.20) When a geyser first begins to erupt, hot water overflows at the orifice and this is followed by a rush of steam, mingled with hot water. The first overflow of hot water aids in the production of steam, because

A. less water needs to be heated.
B. more water can seep into the fissure from the surrounding rocks.
C. it raises the pressure and more steam is produced.
D. the lower the pressure, the lower the temperature at which steam is produced.
E. the water which overflows is necessarily below 212°F. in temperature.

186. (2.20) A tub of water is sometimes placed in a fruit cellar to help prevent the fruit from freezing in cold weather. This is effective because

A. the heat of solidification of water is large.
B. it takes 540 calories to change 1 gm. of water to vapor.
C. water is a good conductor of heat.
D. the condensation of water releases heat.
E. the specific heat of water is smaller than most common substances.

187. (2.20) A thermometer placed in a beaker of water being heated shows a gradual rise until boiling begins. During boiling, it shows a constant reading because

A. heat is given off when a vapor condenses.
B. heat is needed to change a solid to a vapor.
C. the water stops absorbing heat energy.
D. vaporization requires heat.
E. convection currents allow the heat to escape without heating the water

188. (2.20) When a hot iron touches a block of ice, the iron cools but the ice does not warm; some ice melts. The final temperature of the system (iron, ice, and water) is the same as the initial temperature of the ice. From this experiment, one might conclude that

A. since ice has a higher specific heat than iron it will melt with greater speed.
B. the data are false because hot iron and ice cannot be brought into intimate contact without raising the temperature of the ice.
C. heat is a fluid and flows into the ice, thus substantiating the Caloric theory.
D. since heat disappears from the iron, the heat must have been used in changing the ice to water.

189. (2.20) On a very cold day, with freezing temperature, a child who puts a wet hand against a steel fence post is much more apt to have it stick fast than if the post were made of wood. The best explanation of this is that

A. steel has a higher specific heat than wood.
B. steel is a better radiator of heat than wood.
C. steel has a greater specific gravity than wood.
D. steel is a better conductor of heat than wood.
E. steel has a magnetic permeability and wood does not.

190. (2.20) In the laboratory you found that various objects that had been in the room for many hours seemed, when touched, to be at different temperatures. Some objects, in other words, felt colder than others. The reason for this is that

A. heat transfer from the body into various objects occurs at different rates.
B. various objects under these conditions actually contain different quantities of matter.
C. the heat capacity and the temperature of an object are independent of each other.
D. various objects under these conditions actually have different temperatures.
E. various objects under these conditions actually contain different quantities of heat.

191. (2.20) In an experiment two Bunsen burners giving the same kind and type of flame were used. One was placed under a suspended block of iron weighing a pound and the other was placed under a pound of water in a thin-walled vessel. Both materials were heated for the same length of time. Which one of the following conclusions is valid?

- **A.** The iron receives a greater quantity of heat than the water.
- **B.** the temperature of the iron will increase more rapidly than the temperature of the water.
- **C.** Quantity of heat and temperature are the same thing.
- **D.** The kinetic energy of the molecules of water increases more than the kinetic energy of the molecules of iron.
- **E.** None of the above conclusions is valid.

192. (2.20) Although the air temperature may be 10-15 degrees below freezing, when many cars pass over a road covered with fresh snow, a layer of ice is usually formed. The *best* explanation of this phenomenon is:

- **A.** Decreasing the volume of the snow increases the absolute temperature.
- **B.** Friction between the tires and the road raises the temperature above 32°F.
- **C.** Snow is a very poor conductor of heat.
- **D.** Increased pressure lowers the melting temperature of snow.
- **E.** The molecular activity of snow is decreased by the weight of the cars.

193. (2.20) Ice forms at the surface of a body of water because

- **A.** evaporation cools the water near the surface.
- **B.** water at the bottom is kept warm by the layer of water above.
- **C.** water expands slightly upon changing into ice.
- **D.** water at the freezing point is less dense than water slightly warmer.

194. (2.20) If two substances at different temperatures are mixed, the final temperature of the mixture is intermediate. This is best accounted for theoretically on the basis that

- **A.** substances in the same container eventually possess the same average potential energy.
- **B.** on the average, kinetic energy is transferred on collision from particles of higher kinetic energy to those of lower kinetic energy.
- **C.** the average speeds of molecules of different substances become equal after a sufficient number of collisions.
- **D.** all molecules in the same container eventually have the same kinetic energy.

195. (2.30) If a mass of gas is heated

- **A.** it may change its weight.
- **B.** it may increase in volume.
- **C.** it must increase its pressure.
- **D.** it must increase its density.
- **E.** it must increase its volume.

For items 196 - 198 choose from the key list the device or mechanism that is most dependent upon the principle as stated.

KEY

A. Photoelectric cell. **B.** Photographic light meter.
C. Optical pyrometer. **D.** Thermostat.
E. Thermocouple.

196. (2.40) Two metals of different coefficients of linear expansion riveted or welded together will warp or bend under changes in temperature.

197. (2.40) The color and intensity of light emitted from a heated object depend on the temperature of the object.

198. (2.40) An electrical current will flow through two wires of dissimilar metal if the junctions are kept at different temperatures.

For items 199 - 201 select from the key the most closely related principle.

KEY

- **A.** Heat is released when a vapor changes to a solid.
- **B.** Heat is given off when a vapor condenses.
- **C.** Solidification of a liquid releases heat.
- **D.** Vaporization requires heat.
- **E.** Heat is needed to change a solid to a vapor.

199. (2.40) A lid on a steaming kettle soon gets as hot as the contents of the kettle.

200. (2.40) Wet hands feel cold especially on a windy day.

201. (2.40) The heat energy possessed by frost is less than that of rain.

For items 202 - 207 select from the key the one physical principle which is characteristic of the item.

KEY

- **A.** Heat is absorbed when a substance is changed from a solid to a liquid.
- **B.** Air and other gases are poor conductors of heat.
- **C.** Most substances expand when the temperature is increased.
- **D.** Heat is absorbed when a substance changes from a liquid to a vapor.
- **E.** Heat is liberated when a substance changes from a vapor to a liquid.

202. (2.40) Gasoline spilled on the hand makes the hand feel cold.

203. (2.40) Rock wool is a good heat insulating material.

204. (2.40) Ice is used in an ice box to preserve food.

205. (2.40) A thermostat is used as a furnace control.

206. (2.40) Steam at 212°F. will burn the hand more severely than water at 212°F.

207. (2.40) Tires are more likely to blow out in summer than in winter.

Items 208 - 214 refer to practical application of the principles of heat energy. For each item select from the key the most appropriate response.

KEY

- **A.** Heat is absorbed when a solid changes to a liquid.
- **B.** Heat is absorbed when a liquid changes to a gas.
- **C.** Heat is absorbed when a liquid is increased in temperature.
- **D.** Heat is liberated when a liquid is solidified.
- **E.** Heat is liberated when a gas is condensed to a liquid.

208. (2.40) A wet compress feels good on the head of a person ill with a fever.

209. (2.40) An ordinary electric refrigerator never cools the room in which it is placed.

210. (2.40) Under standard conditions, turning up a gas flame does not raise the temperature of boiling water.

211. (2.40) The basic principle of how a steam radiator is heated.

212. (2.40) Even when the weather is very cold, bodies of water still tend to moderate the climate.

213. (2.40) A swimmer just out of the water feels cool on a breezy day.

214. (2.40) The cooling principle used in electric home freezers.

215. (1.10) The temperature at which a liquid boils may be raised by

- **A.** insulating the container.
- **B.** covering with an airtight cover.
- **C.** removing the vapor from the surface above the liquid.
- **D.** changing the type of container from metal to glass.
- **E.** adding a low-boiling-point liquid to form a solution.

216. (2.40) Which of the following situations involves a direct application of the principle that materials change volume with changes in temperature?

- **A.** All of the following.
- **B.** Some rocks are reduced to sand by disintegration.
- **C.** Automobile pistons require lubrication.
- **D.** The lead in wires for electric light bulbs is made of invar.
- **E.** Glass containers will break if subjected to sudden temperature changes.

217. (2.40) An explanation of why an ordinary glass jar is apt to break when boiling water is poured into it would have to include the concept that

- **A.** the specific heat of water is higher than that of glass.
- **B.** glass is a very poor conductor of heat.
- **C.** the coefficient of expansion of water is greater than that of glass.
- **D.** glass appears to be a supercooled liquid and its structural characteristics undergo changes at a temperature of 212°F.
- **E.** the construction of heat proof glass requires a special formula.

218. (2.40) An explanation of why a layer of frost damages vegetation more than a layer of water at the same temperature would involve the concept that

- **A.** heat is released when a vapor changes to a solid.
- **B.** heat is given off when a vapor condenses.
- **C.** solidification of a liquid releases heat.
- **D.** vaporization requires heat.
- **E.** heat is needed to change a solid to a vapor.

219. (2.40) From the generalization that, "The pressure of a gas approaches zero as its temperature approaches −273°C.", it is possible to deduce that

- **A.** at a temperature of −273°C. all gases would become solids.
- **B.** at a temperature of −273°C. the gas molecules would lose their kinetic energies completely.
- **C.** at a temperature of −273°C. the gas would have absolutely no weight.
- **D.** at a temperature of −273°C. the gas would have absolutely no volume.
- **E.** more than one of the above could be correct.

220. (3.00) 200 gm. of lead was placed in a specially built calorimeter containing an electrical heating device. By means of this device, heat was supplied to the lead at the rate of 100 calories per minute. It was observed, that while the lead was melting, the temperature remained constant for 10 minutes. Based on this data, the heat of fusion of lead is approximately

A. 0.5 cal./gm. **B.** 100 cal. **C.** 5 cal./gm.
D. 1000 cal. **E.** none of these.

Items 221 - 223 refer to problems in heat. Use any of the following constants which you have need for in their solution.

Specific heat of ice	0.5 cal./gm./°C.
Specific heat of water	1.0 cal./gm./°C.
Specific heat of steam	0.45 cal./gm./°C.
Specific heat of aluminum	0.22 cal./gm./°C.
Latent heat of fusion of ice	80 cal./gm.
Latent heat of vaporization of water	540 cal./gm.

221. (3.00) If it were possible to apply 1 calorie of heat to 1 gm. of ice at −10 C.,

- **A.** 1/80 of a gm. of ice would melt without any change in temperature.
- **B.** the ice would be raised in temperature to 0°C.
- **C.** the ice would be raised in temperature to −5°C.
- **D.** the ice would be raised in temperature to −8°C.
- **E.** the ice would be raised in temperature to −9°C.

222. (3.00) To change 10 gm. of steam at 100°C. and 1 atmosphere pressure to water at 90°C. and 1 atmosphere pressure would release

A. 5400 calories. **B.** 5445 calories.
C. 5500 calories. **D.** 585 calories.
E. 640 calories.

223. (3.00) If 100 gm. of water at 40°C. were contained in an aluminum cup weighing 100 gm., the cup also being at 40°C., cooling the cup and its contents to 0°C. would release

A. 4880 calories. **B.** 8000 calories.
C. 4022 calories. **D.** 4000 calories.
E. 8080 calories.

224. (3.00) When the condenser coils of a household refrigerator are warm to the touch, one should conclude that

- **A.** it is time to defrost the refrigerator.
- **B.** the refrigerator is operating efficiently.
- **C.** more refrigerant is needed in the coils.
- **D.** the float in the float chamber is stuck.
- **E.** too much warm food has been placed on the shelves.

For items 225 - 227 select from the key the most appropriate response.

KEY

A. 76 cm. of mercury. **B.** 152 cm. of mercury.
C. Between 76 and 152 cm. of mercury.
D. Greater than 152 cm. of mercury.
E. There is not sufficient information to calculate the pressure.

225. (3.00) A quart jar is half full of water, the other half containing air at a pressure of 76 cm. of mercury. If the jar is sealed at 20°C. and then placed in a vessel of water which is brought to the boiling point, what is the final pressure in the jar?

226. (3.00) If the jar contains only water and its vapor and is sealed at 20°C. and placed in the vessel of water which is brought to the boiling point, what is the final pressure in the jar? Assume that the jar contains sufficient water so that some remains in the liquid state.

227. (3.00) If the same jar contains air and only a very small amount of water, so that all of the water evaporates during the heating process, and is sealed at 20°C. and placed in the vessel of water which is brought to the boiling point, what is the final pressure in the jar?

228. (3.00) If heat were applied to a piece of ice at —15°C. until the final temperature were 105°C., in which one of the following temperature intervals would the *least* amount of heat be required to produce the change in temperature indicated? The specific heat of ice is .5.

A. —15°C. to —5°C. **B.** —5°C. to +5°C.
C. 45°C. to 55°C. **D.** 95°C. to 105°C.
E. All of the above require the same amount of heat.

Items 229 and 230 are based upon the following situation:

The boiling and freezing points of water were determined and marked on the glass of a new, and as yet "blank" thermometer. If these two points are 9 inches apart, how far apart would the degree marking be if it were desired to make

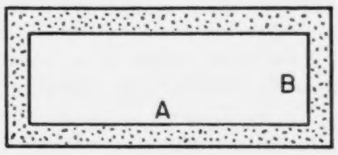
229. (3.00) a Centigrade thermometer?

A. 9/180 inch. **B.** 0.09 inch. **C.** 0.9 inch.
D. 9/16 inch. **E.** 9/32 inch.

230. (3.00) A Fahrenheit thermometer?

A. 0.05 inch. **B.** 0.5 inch. **C.** 0.09 inch.
D. 9/100 inch. **E.** 9/32 inch.

231. (3.00) The diagram represents a rectangular annealed brass plate in which there is cut a rectangular hole, of dimensions (at 0°C.) as indicated. If now the temperature of the plate is raised to 150°C.,



A. *a* will increase, while *b* decreases.
B. both *a* and *b* will decrease.
C. *b* will increase while *a* decreases.
D. both *a* and *b* will increase.
E. the new dimensions of the *hole* will depend upon the original outside dimensions of the *plate itself*.

Items 232 - 236.

A calorimeter of weight 100 gms. and specific heat 0.1 contains 500 gms. of water at 15°C. After a block of metal weighing 50 gms. and at a temperature 1020°C. is dropped in, the temperature rises to 20°C.

232. (3.00) The number of calories gained by the water is

A. 500. **B.** 1000. **C.** 2000. **D.** 2500.
E. 10,000.

233. (3.00) The number of calories gained by the calorimeter is

A. 50. **B.** 100. **C.** 200. **D.** 5000.
E. 1000.

234. (3.00) The number of calories lost by the block is

A. 0. **B.** 400. **C.** 2200. **D.** 2550. **E.** 9500.

235. (3.00) The number of calories lost by each gram of the block is

A. 8. **B.** 44. **C.** 51. **D.** 190. **E.** 0.

236. (3.00) The specific heat of the metal is

A. 0. **B.** 0.008. **C.** 0.051. **D.** 1.90.
E. 4.4.

237. (3.00) If two metal balls of the same size and material, one polished and the other blackened are heated to the same temperature and placed in a refrigerator

A. the blackened one cools more rapidly than the polished one.
B. the polished one cools more rapidly than the blackened one.
C. they cool at the same rate.
D. they will never come to the same temperature.
E. none of these statements is necessarily true.

238. (3.00) 75 calories of heat flow in one second through each square centimeter of the bottom of an aluminum pan 2 millimeters thick. If the temperature is 130°C. on one side and 100°C. on the other, the coefficient of thermal conductivity of the aluminum is, in metric units

A. 2.5. **B.** 0.1. **C.** 0.5. **D.** 0.0048.
E. 0.125.

Item 239 deleted.

240. (3.00) Five grams of ice at —10°C. is heated until it is steam at 120°C. The specific heat of both ice and steam is 0.5. The heat required in the process is about

A. 3270 cals. **B.** 3670 cals. **C.** 3170 cals.
D. 2685 cals.

241. (3.00) Would the air in a closed room be heated or cooled by the operating of an electric refrigerator in the room with the refrigerator doors open?

A. Heated, because the heat given off by the motor and the compressed gas would exceed the heat absorbed.
B. Cooled, because the refrigerator is a cooling device.
C. Cooled, because compressed gases expand in the refrigerator.
D. Cooled, because liquids absorb heat when they evaporate.
E. Not heated or cooled.

Items 242 and 243 are based on this situation. A householder is interested in increasing the efficiency of his heating system, consisting of a gas burner used in conjunction with a circulating hot water system. He knows that the combustion of the fuel used is approximated closely by the equation $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$ in which CH_4 is methane gas. The methane and air (20% oxygen) are forced into the furnace from separate pipes.

242. Some liquids heat more quickly than water; that is, they
(3.00) require less heat for the same temperature rise. Is there a great advantage in circulating such liquids?

- **A.** No; they would also release less heat on cooling.
- **B.** No; they would produce excessive heat throughout the house.
- **C.** No; they would boil at too low a temperature.
- **D.** Yes; less fuel would be needed for the same heating effect.
- **E.** Yes; they would retain their heat better and reduce the amount of insulation needed.

243. For most efficient transfer of heat, water pipes in a
(3.00) furnace should

- **A.** be coated with a white heat-resisting enamel.
- **B.** be covered with asbestos.
- **C.** have a rough blackened surface.
- **D.** have a bright polished surface.
- **E.** be blacked inside and brightly polished outside.

Items 244 - 245 contain pairs of statements which are either in agreement with each other or not in agreement, and either one of the statements may be true or false. For each item select from the key the correct response.

KEY

- **A.** Statement I and II are in agreement and both false.
- **B.** Statement I and II are in agreement and both true.
- **C.** Statement I and II are not in agreement; I true, II false.
- **D.** Statement I and II are not in agreement; I false, II true.

244. I. At absolute zero the molecules of a substance do not
(4.20) move with respect to each other.
II. No heat energy is possessed by a substance at absolute zero.

245. I. If an air mass expands isothermally, its temperature
(4.20) will rise.
II. Heat must be added in the isothermal expansion of air.

246. A laboratory experiment to determine the specific heat
(4.20) of a metal yielded the following data.

Weight of metal	240.9 gm.
Weight of calorimeter cup and stirrer	289 gm.
Weight of water	400 gm.
Temperature change of water	2.4°C.
Temperature change of metal	100°C.

The experimenter cannot proceed with calculations until he determines

- **A.** the original temperature of the water.
- **B.** the final temperature of the water.
- **C.** the specific gravity of the metal.
- **D.** some other additional data.
- **E.** no additional data. He can proceed with calculations.

For items 247 through 249 the key presents brief references to experiments and demonstrations of traditional significance in physical science. Recall the observations and conclusions of the total experiment and indicate which activity yields the most information toward explaining the situations described in the statement.

KEY

- **A.** A pycnometer was filled with water and carefully weighed.
- **B.** The extension produced in a spring by the rotation of an attached weight was recorded.
- **C.** A weight was suspended and then allowed to fall in such a way as to leave equal time interval marks on sensitive paper.
- **D.** The weight and temperature of a cup of water was recorded before and after a known amount of electricity had flowed through a resistance immersed in the water.
- **E.** The weight and temperature of a cup of water was recorded before and after a cube of ice was melted in it.

247. Farmers sometimes place a tub of water in cellars where
(4.20) potatoes are stored.

248. A hydrometer can be used to estimate the freezing tem-
(4.20) perature of the coolant in an automobile radiator.

249. The temperature of a mass of water will rise if placed
(4.20) in a container and agitated.

250. A student puts his right hand into a vessel of cold water
(4.20) and his left hand into a vessel of hot water. After a minute he puts both hands into a vessel of luke-warm water. To his surprise he discovers that the right hand now feels warm and the left hand feels cool. This illustrates a basic characteristic of the temperature sense. From this information we may conclude that

- **A.** objects warmer than body temperature may occasionally contain a smaller quantity of heat than objects cooler than body temperature.
- **B.** the heat capacity of warm water is less than that of cold water.
- **C.** whether an object feels hot or cold depends on the quantity of heat it contains.
- **D.** the amount of heat gained from the luke-warm water by the right hand equals the amount of heat lost by the left hand.
- **E.** whether a particular object feels warm or cold depends on whether heat is transferred from object to observer or in the reverse direction.

251. A coal dealer needed to know the amount of heat
(4.20) evolved in the complete combustion of a certain type of coal. A sample of the coal was placed in a thin metal capsule, the capsule was filled with oxygen and then sealed. After immersing the capsule in an insulated vessel of water the contents were ignited by an electric spark. The heat evolved was determined by observing the temperature of the water surrounding the capsule. Which of the following observations is *least* essential for a fairly accurate determination of the heat evolved by the type of coal in question?

- **A.** Weight of coal sample. **B.** Weight of water.
- **C.** Weight of the capsule.
- **D.** Final temperature of the water.
- **E.** Time required for combustion.

252. In the preceding item the amount of oxygen used in
(4.20) the capsule must be

- **A.** only enough to start the coal to burn.
- **B.** enough to completely burn the coal.
- **C.** enough to completely burn the coal and the capsule.
- **D.** the same weight as the coal.

Items 253 - 257. The following passage concerns the caloric theory of heat. The items concern an evaluation of the theory. Read the passage carefully before answering.

The caloric theory of heat was the most widely accepted theory of heat in the early 19th century. It was recognized by a large majority of the leading men of science, many of whom contributed greatly to the advance of science in their time. It stated:

a. Heat was a fluid, caloric, which was made up of particles or corpuscles.
b. The corpuscles were able to push their way between the particles (molecules) of matter.
c. The corpuscles were mutually repellent (much as the electrons of negative electricity).
d. All matter attracted the corpuscles but some matter more strongly than other matter.
e. The fluid was indestructible and *could not be created.*

Select from the key the most appropriate phrase. (Assume the caloric theory to postulate only the points given above.)

KEY

A. The statement is *true* and *can* be explained by both the caloric theory and the kinetic theory.
B. The statement is *true* and *can* be explained by the kinetic theory but not by the caloric theory.
C. The statement is *false* and can be shown to be false by *either* the kinetic or caloric theories.
D. The statement is *false* but if true would be a point in favor of the caloric theory.

253. (4.20) When two substances of unequal temperature are placed in contact the colder one is warmed and the warmer one cooled.

254. (4.20) Only a certain amount of heat may be obtained from a body by friction, when that body is rubbed, even though the friction does not continue long enough to wear the body away.

255. (4.20) Iron expands when it is heated.

256. (4.20) Two cakes of ice may be melted by friction if they are rubbed together rapidly even though the temperature of the surroundings is below 32 degrees F.

257. (4.20) Milk when churned will rise in temperature.

Items 258 - 267. The following paragraphs concern the action of a geyser. Read the passage carefully and answer the items by using the key.

A geyser is a hot spring that erupts at intervals. It is made up of a more or less crooked or constricted, tubular fissure that extends into the earth and is filled with water. A source of heat near the bottom of the fissure heats the water.

After an eruption the tube fills with water from an underground source. The water throughout most of the length of the tube, and especially in the lower part, becomes heated to a point above the normal boiling temperature (212°F.) of water but does not become quite hot enough to turn to steam. However, sooner or later, some of the water in the lower part of the tube at the source of heat reaches the boiling point and turns to steam. The steam raises the whole column of water above it and causes some water to overflow from the geyser pool at the surface. This overflow acts as a trigger, permitting the whole column of water in the tube to flash into steam which blows from the fissure in an eruption.

KEY

A. Statement is *true* and pertains directly to the action of the geyser.
B. Statement is *true* but is not directly concerned with the action of the geyser.
C. Statement is *false.*

258. (4.20) If the tube were not crooked and constricted the water throughout the tube would come to nearly the same temperature by unrestricted convectional circulation, the water would boil, and a boiling spring rather than geyser would result.

259. (1.10) Water has one of the lowest specific heats of any common substance.

260. (1.10) Convection is inhibited in liquids of low viscosity.

261. (1.10) The boiling point of water in the bottom of the tube is lower than that at the top.

262. (2.10) The water in the tube does not turn to steam although it is above the normal boiling point because of the pressure of the overlying water.

263. (2.20) More heat is necessary to turn the water to steam at the bottom of the tube than at the top.

264. (1.10) Water at the top of the tube (at the surface of the geyser pool) can be raised above its boiling point solely by the application of more heat after the water has been made to boil.

265. (1.10) If salt were added to the water the boiling point of the water would be lowered.

266. (2.10 The geyser erupts because the overflow of water releases pressure throughout the whole tube, lowering the boiling point at all levels sufficiently to allow the water to turn to steam.

267. (4.20) Air pressure on a fine day is usually higher than on a stormy day. Thus the geyser will erupt more often during stormy weather.

268. (4.20) Two identical samples of a gas (1 and 2) at the same initial temperature were heated to the same final temperature under the following conditions:

Gas 1 at constant volume.
Gas 2 at constant pressure.

Which one of the following is true?

A. Sample 1 required more heat than sample 2.
B. Sample 2 required more heat than sample 1.
C. Both samples required the same amount of heat.
D. The answer cannot be determined without knowing the kind of gas.

20. *Electricity and Magnetism*

ELECTRICITY AND MAGNETISM

1. (1.10) Direct current is produced by a dynamo equipped with

A. a commutator from which the current is collected.
B. a stator from which the induced current is drawn.
C. solid ring contacts from which the current is collected.

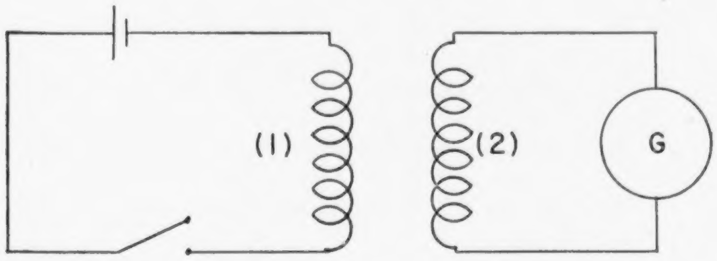
2. (1.10) An electromagnet consists of a coil of wire around a core of

A. soft iron or special alloy. **B.** steel. **C.** copper.

3. (1.10) Silver plating requires setting up an electroplating cell. The silver spoon to be plated must be

A. the cathode. **B.** the anode.
C. either anode or cathode.

Items 4 - 6 refer to the following circuit.



4. (1.10) An induced current will be produced in (2)

A. only when the key is closed.
B. only when the key is opened.
C. only when the key is kept closed.
D. under no circumstances of opening or closing the key.
E. whenever the key is closed or opened.

5. (1.30) Whenever a current is induced in the circuit, all of these statements are true *except*

A. the voltage of coil (2) need not be the same as that of coil (1).
B. Lenz's law applies to the circuit.
C. the current in coil (2) will be in the same direction as that in coil (1).
D. this principle is applied in the induction coil.
E. the current in coil (2) will alternate on closing and opening the key

6. (2.10) If coil (1) had 100 turns of wire and coil (2) had 400, whenever a current is induced

A. the electric power in coils (1) and (2) will be about the same.
B. the voltage in coil (2) will be ¼ as large as that in coil (1).
C. the current in both coils will be the same.
D. the current in coil (2) will be 4 times as large as that in coil (1).
E. the voltage in both coils will be about the same.

7. (1.10) The chief function of a generator in a simple circuit is to

A. act as a flood gate in a water system.
B. maintain a potential difference.
C. manufacture electrons.
D. give electrons negative charges.
E. furnish protons to the circuit.

8. (1.10) Electric current is applied to or led from the movable portion of electric motors by means of the

A. brushes. **B.** commutator. **C.** slip ring.
D. armature. **E.** field coil.

9. (1.10) Iron is used in the cores of transformers rather than copper because

A. iron can withstand a higher temperature.
B. iron has greater resistance than copper.
C. iron has a very high permeability.
D. iron makes a good permanent magnet.
E. iron insulates the primary from the secondary.

10. (1.10) Most cities use alternating current but some parts of New York City are furnished with direct current. Direct current, even though of suitable voltage, will *not* operate

A. an electric iron. **B.** an electrolysis outfit.
C. a transformer. **D.** any type of electric motor.
E. an electromagnet.

11. (1.10) Sound pulsations are transformed to electrical pulsations in a

A. photoelectric cell. **B.** telephone receiver.
C. transformer. **D.** radio tube. **E.** microphone.

12. (1.10) Internal combustion engines depending upon electrical ignition must have either a generator or magneto for continued operation. Which of the following is required for starting engines fitted with generators that is not required for engines fitted with magnetos?

A. An auxiliary source of electric power.
B. Larger permanent magnets.
C. More coils on the armature.
D. Two or more brushes. **E.** Protective fuses.

13. (1.10) The electric motor of an electric refrigerator will often burn out if the current in the house circuit diminishes for any length of time but does not completely fail (this diminished current is indicated by the dimming of the lights in the house). This is because

A. electric motors must have at least 110 volts to operate without burning out.
B. a drop in the amperage through the armature is accompanied by an increase in voltage.
C. a decrease in the current in a wire raises the resistance in the wire which in turn causes heating. ($i = e/r$)
D. the field coils become highly magnetized causing the motor to run faster.
E. the resistance to the current in the coils of the armature is greater when the motor is running fast than when running slowly.

14. (1.10) A current of electrons in a long straight wire *always*

A. creates a field of force in such a manner that the north pole of a magnet in that field will point to the wire.
B. creates an alternating expanding and contracting field around the wire.
C. flows from the positive terminal of the generator around the circuit to the negative terminal.

D. creates a field of force in the form of circles around the wire which lie in planes perpendicular to the wire.
E. creates a field whose intensity is in direct proportion to the distance from the wire.

15. (1.10) That the direction of an induced current is such as to set up a magnetic field which opposes the motion producing the current is in accord with

A. Snell's law. **B.** Wien's law. **C.** Faraday's law.
D. Lenz's law. **E.** Ampere's law.

16. (1.10) One would expect to find a *field of force* around

A. a wire carrying an electrical current.
B. a positive electrical charge.
C. a magnetic north pole.
D. a planet in the solar system. **E.** all of the above.

17. (1.10) The secondary coil of a transformer will produce

A. alternating current always.
B. direct current always.
C. alternating current part of the time and direct current part of the time.
D. always a higher voltage than the primary coil.
E. more power than is put into the primary.

18. (1.10) When a magnetic field is cut by a wire, a current is induced in the wire. This is an example of

A. electrostatic induction. **B.** Edison effect.
C. electromagnetic induction.
D. electrolytic reduction.

19. (1.10) A direct current motor always differs from an alternating current motor in that it has

A. an armature. **B.** a shunt. **C.** brushes.
D. a commutator.

After the number on the answer sheet corresponding to that of each of the following paired items, blacken space

A if the magnetic field due to the thing referred to in the item at the left is greater than that produced by the thing referred to in the item at the right.
B if the magnetic field due to the thing referred to in the item at the right is greater than that produced by the thing referred to in the item at the left.
C if the magnetic field due to the things referred to in both items are of about the same magnitude.

20. (1.10)	A coil carrying current.	....	The same coil and current, but coil has an iron core.
21. (1.10)	A coil of 100 turns carrying two amperes of current.	....	A coil of 50 turns carrying four amperes of current.
22. (1.10)	A stationary charge.	....	The same charge moving.
23. (1.10)	A 500 watt transformer.	....	A 10 kilowatt transformer.

24. (1.10) Iron is used in preference to copper in cores of magnets of dynamos and motors because

A. copper is magnetic and iron is not.
B. iron conducts electricity better than copper.
C. iron is magnetic while copper is not.
D. copper is heavier than iron.
E. iron is more resistant to corrosion than copper.

25. (1.10) A transformer will *not* operate when the current in the primary is

A. changing. **B.** increasing. **C.** decreasing.
D. constant. **E.** alternating.

26. (1.10) Which part of a D.C. generator causes it to deliver a direct rather than an alternating current?

A. Brushes. **B.** Armature. **C.** Slip rings.
D. Commutator. **E.** Electromagnets.

27. (1.10) The south pole of any magnet is directed toward

A. 70° South latitude south of Australia.
B. 71° North latitude near Hudson's Bay.
C. the south geographic pole.

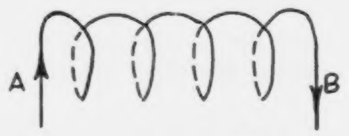
28. (1.10) When a permanent magnet is broken into two pieces the result is,

A. two smaller magnets, each having a north and a south pole.
B. a magnet having only a north pole and another having only a south.
C. demagnetization.

29. (1.10) Permanent magnets are used in

A. doorbells. **B.** magnetic lifting cranes.
C. telephones.

30. (1.10) In a coil of wire the direction of the electrons is as indicated by arrows. Which end of the coil is the north pole?



31. (1.10) Whether a material can be magnetized depends entirely upon whether or not

A. it is composed entirely of iron.
B. the particles of which it is composed are magnetic.
C. it is composed at least partially of iron.
D. it is composed of iron rather than steel.
E. it has been exposed to high frequency alternating electrical currents.

32. (1.10) *Magnetic declination* is

A. a process for shielding a compass from local magnetic effects so that it will point toward the magnetic north pole.
B. a map showing the differences between magnetic north and true north.
C. the angle formed with the horizon by a magnetic needle free to move vertically.
D. the horizontal angle between magnetic north and true north.
E. the direction in which a compass needle normally points.

33. (1.10) The best substance to shield a watch from the influence of a magnet is

A. lead. **B.** gold. **C.** glass. **D.** iron.
E. transparent plastic.

34. (1.10) A piece of iron brought near a magnet becomes magnetized because of

A. ionization. **B.** induction. **C.** polarization. **D.** electrification. **E.** conduction.

35. (1.10) When a magnet is brought near an iron nail, the nail becomes magnetized because

A. of conduction of electric charges from the magnet to the nail.
B. the nail has para-magnetic properties.
C. of magnetic induction.
D. magnetic flux was present in the nail originally.
E. the nail is made of iron.

36. (1.10) All of these metals are ferro-magnetic *except*

A. cobalt. **B.** nickel. **C.** lead. **D.** iron. **E.** steel.

37. (1.10) From your understanding of the properties of magnets, and of the phenomena of magnetism select the *one* item in the following question which is *not* correct, or which *can not* be applied to magnetism or in the magnetic theory.

A. The poles of a magnet are completely uninfluenced by a stationary electric charge.
B. There is no such thing as a free magnetic pole.
C. Nearly all metallic substances exhibit the property of magnetism.
D. The greatest part of the magnetism of a bar magnet is concentrated near the ends.
E. It may be assumed that magnetism is a property of the smallest particles of a substance.

Items 38 - 42. Use the following key.

KEY

A. Applies only to electric charges, and not to magnetic poles.
B. Applies only to magnetic poles, and not to electric charges.
C. Applies to *both* electric charges and magnetic poles.
D. Applies to *neither* electric charges nor to magnetic poles.

38. (1.10) Likes repel and opposites attract.

39. (1.10) Align themselves along a N.-S. direction if free to move.

40. (1.10) Can move along a conductor.

41. (1.10) Always occur in sets or pairs.

42. (1.10) The force between the charges is directly proportional to the distance between them.

43. (1.10) In accordance with our present theory of atomic structure, magnetism may best be explained by

A. the whirling electrons in atoms.
B. the unequal declination of the earth.
C. the radioactive disintegration.
D. the existence of the north magnetic pole.

Statement: A permanent magnet is heated.

44. (1.10) *Effect:*

A. The magnet becomes an electrical conductor.
B. The magnet loses some of its magnetism.
C. The north poles are formed.
D. The north pole becomes a south pole.
E. The magnet acquires more magnetism.

45. (1.10) *Cause:*

A. Heating a piece of steel decreases the electrical resistance.
B. Passing a current through a conductor creates a magnetic field.
C. Heating causes an increase in the velocity of gas molecules according to the molecular theory.
D. Heating increases the vibration of the molecules and disturbs the orderly arrangement found in magnets.
E. The magnets within the molecules reverse direction.

Statement: A piece of soft iron is placed between the poles of a horseshoe magnet.

46. (1.10) *Effect:*

A. The poles of the magnet are forced outward.
B. The soft iron core ionizes the air.
C. The magnetic field about the poles changes to an electrostatic field.
D. The lines of force are concentrated through the soft iron core.
E. The magnet loses part of its magnetism.

47. (1.10) *Cause:*

A. The core offers less resistance to the lines of force than the air.
B. Soft iron is a better magnet than steel.
C. The lines of force cannot pass through the air.
D. The core is attracted to the north pole.
E. The core assumes a north-south direction.

48. (1.10) Which one of these metals is ferro-magnetic?

A. Zinc. **B.** Lead. **C.** Silver. **D.** Nickel. **E.** Copper.

49. (1.10) All these metals are magnetic except

A. cobalt. **B.** nickel. **C.** lead. **D.** steel. **E.** iron.

50. (1.10) The magnetization of a steel rod in a magnetic field is

A. always very slight.
B. often increased by repeated tapping.
C. independent of any treatment of the rod.
D. the same in any field.
E. less than that of a bronze rod.

51. (1.10) When a magnet is held close to iron filings, they

A. will be attracted by the north pole and repelled by the south pole of the magnet.
B. will be repelled by both poles of the magnet.
C. will be attracted by the south pole and repelled by the north pole.
D. will be attracted by both poles.
E. will not be affected by either pole.

Items 52 - 56. Each of the items begins with a phrase specifying something to be measured, determined, or produced. After the item number on the answer sheet, blacken the *one* numbered space which designates how this goal is to be accomplished.

52. (1.10) The amount of electric charge on a single electron:

A. use an electroscope. **B.** use a cathode tube.
C. use a fog-track apparatus.
D. use Millikan's oil drop apparatus.
E. use the mass spectrograph of Aston.

53. (1.10) Whether the nucleus of an atom is small as compared with the total volume of the atom:

A. use Millikan's oil drop apparatus.
B. shoot alpha particles through gold foil or use the fog-track apparatus.
C. use a zinc sulfide fluorescent screen.
D. use the mass spectrograph of Aston.
E. use the Geiger counter.

54. (1.10) Whether or not a given element has isotopes:

A. seek chemical reactions which will separate different forms.
B. use the fog-track apparatus.
C. use the mass spectrograph of Aston.
D. use a centrifuge so that the heavier atoms will be separated from the lighter ones.
E. use a zinc sulfide fluorescent screen.

55. (1.10) Whether or not a given particle, known to be an electron or a positron, is the latter rather than the former:

A. observe its path in a zinc sulfide fluorescent screen.
B. use the mass spectrograph of Aston.
C. observe its path in a fog-track apparatus in the presence of a magnetic field.
D. pass the particle through beryllium foil and observe the results.
E. observe the direction in which it circles around the nucleus.

56. (1.10) Whether or not neutrons are present:

A. use the Geiger counter.
B. look up evidence of collisions in which there is no fog-track up to the collision.
C. use the oil drop apparatus of Millikan.
D. use deuterons in the atom smashing experiment.
E. compare the observable path of the neutron with that of the electron and proton.

57. (1.10) The unit of electric power is the watt. Which of the following is correct?

A. Watts = amperes/volts.
B. Watts = ohms/volts.
C. Watts = volts × amperes.

Items 58 - 62. Select the correct answer from the key.

KEY

A. Edison effect. **B.** Photoelectric effect.
C. Both effects. **D.** Neither effect.

58. (1.10) Electrons move across a gap in one direction only.

59. (1.10) The effect indicates the nature of the electric current.

60. (1.10) Electrons are emitted from a hot filament.

61. (1.10) A potential must be maintained between the source of electrons and the plate or loop which receives them.

62. (1.10) Electrons are emitted by a metal or a compound when exposed to light.

63. (1.10) During the electroplating of a number of silver spoons, 107.88 grams of silver are used. This would require

A. 900,000 coulombs. **B.** one coulomb.
C. 96,500 coulombs. **D.** 85,000 coulombs.
E. none of these.

Items 64 - 71. Select the correct answer from the key.

KEY

A. Direct current. **B.** Alternating current.
C. Neither type. **D.** Both types.

64. (1.10) It will operate a motor which has no rings or brushes.

65. (1.10) This kind of current must be used in electroplating.

66. (1.10) This type of current is obtained when electrons are emitted from a hot filament.

67. (1.10) It consists of electrons in motion.

68. (1.10) Motors using this type of current start more readily under a heavy load and their speed is more easily controlled.

69. (1.10) This type of current will operate an electric heater.

70. (1.10) This type of current cannot be used to produce a magnetic field.

71. (1.10) The voltage of this type of current can be readily raised or lowered by means of a transformer.

Items 72 - 73. Select the correct answer from the key.

KEY

A. Watts. **B.** Joules. **C.** Volts. **D.** Coulombs.
E. Amperes.

72. (1.10) The total quantity of electricity is expressed in________.

73. Potential difference is expressed in________.

Items 74 - 75. Select the correct answer from the key.

KEY

A. Charged storage battery.
B. Discharged storage battery.
C. Charged Daniell Cell.
D. Discharged Daniell Cell.
E. Discharged Edison battery.

74. (1.10) Zinc ions are in solution, metallic copper has been deposited, and chemical energy has all been changed to electrical energy.

75. (1.10) Electrodes are covered with a deposit of lead sulfate, and the electrolyte is sulfuric acid of 1.15-1.17 specific gravity.

Items 76 - 81. Select the correct answer from the key.

KEY

A. Leyden jar. **B.** Battery. **C.** Both.
D. Neither.

76. (1.10) Is of practical use.

77. (1.10) Requires expenditure of energy.

78. (1.10) Discharge violent and complete.

79. (1.10) Likely to have a high potential.

80. (1.10) Electrical energy is due to chemical reaction.

81. (1.10) Discharge steady and may be repeated within limits.

Items 82- 89. Select the correct answer from the key.

KEY

A. Edison Cell. **B.** Dry Cell. **C.** Voltaic Cell.
D. All of these. **E.** None of these.

82. (1.10) The negative electrode is copper.

83. (1.10) The positive electrode is carbon.

84. (1.10) Can be recharged.

85. (1.10) A storage battery.

86. (1.10) No liquid is present.

87. (1.10) The electrolyte is a base.

88. (1.10) Can be operated only as an electrolytic cell.

89. An oxidization-reduction reaction occurs while cell is in operation.

90. (1.10) When a charged rubber rod is held near a neutral pith ball, the ball will be attracted to the rod because

A. a magnetic field of force surrounds the rod.
B. the rod is larger than the ball.
C. electrons are removed from the ball.
D. protons are added to the ball.
E. a charge is induced on the ball.

91. (1.10) When a body has been charged positively with static electricity

A. it contains no electrons.
B. positive charges move to it.
C. it must be metallic in nature.
D. it is deficient in electrons.
E. protons were added to it.

92. (1.10) Which of the following sentences describes most accurately the way an electric current moves along a metallic conductor?

A. Electrons become dislodged from an atom and are attracted to the electrons of neighboring atoms.
B. Electrons are dislodged from an atom and electrons from neighboring atoms move in to replace them.
C. Electrons are dislodged from the nucleus of an atom and the unsatisfied protons pull neighboring electrons into the nucleus.
D. Protons become dislodged from the nucleus of an atom and move to re-establish equilibrium.
E. Electrons exchange places within the orbits of the same atoms.

93. (1.10) In electroplating silver, the silver is deposited on the

A. negatively charged electrode.
B. electrode nearest the battery.
C. larger electrode.
D. electrode already containing some silver.
E. positively charged electrode.

94. (1.10) To give a body a positive charge of electricity

A. some neutrons must be removed.
B. some positrons must be removed.
C. some electrons must be added.
D. a change in nuclear content must be produced.
E. some electrons must be removed.

95. (1.10) When an amber or hard rubber rod is given a negative charge of electricity by rubbing with wool or fur

A. positive charges are removed from the rod and transferred to the wool.
B. negative charges are removed from the rod and transferred to the wool.
C. positive charges are removed from the wool and transferred to the rod.
D. negative charges are removed from the wool and transferred to the rod.
E. none of these happens.

96. (1.10) A thermionic valve is

A. a thermocouple. **B.** a photoelectric cell.
C. a radio tube. **D.** an electroscope.
E. a pyrometer.

97. (1.10) The time rate of flow of a quantity of electricity is called

A. a kilowatt-hour. **B.** an ampere. **C.** a coulomb.
D. a volt. **E.** an oersted.

98. (1.10) When a potential is applied to the two carbon electrodes of a cell containing HCl solution,

A. electrons flow directly from the positive terminal of the source of potential to the cell's positive electrode.
B. hydrogen moves to the positive terminal of the cell.
C. chloride ions are oxidized to chlorine atoms.
D. chloride ions migrate to the negative terminal of the cell.
E. chlorine atoms become chloride ions.

99. (1.10) A rectifier is a device for changing

A. chemical energy into electrical energy.
B. potential energy into kinetic energy.
C. alternating current to direct current.
D. low voltage to high voltage.
E. mechanical energy into electrical energy.

100. (1.10) Frequency Modulation (FM) is a means of

A. increasing the speed of jet propelled aircraft.
B. transmitting radio programs.
C. reducing the glare in electric lighting.
D. transmitting sounds on a beam of light.
E. eliminating echoes in large rooms.

101. (1.10) The statement that one joule of work is required to move a charge of one coulomb from one point to another is a definition of

A. a watt. **B.** an ohm. **C.** an ampere.
D. an oersted. **E.** a volt.

102. (1.10) When an electric current flows through a resistance, the energy is expended as

A. chemical energy. **B.** amperes. **C.** volts.
D. sound. **E.** heat.

103. (1.10) An electric current will flow through two wires of dissimilar metal in a closed circuit if the junctions are kept at different temperatures. This is the principle applied in the operation of

A. a photoelectric cell.
B. a photographic light meter.
C. an optical pyrometer. **D.** a thermostat.
E. a thermocouple.

For items 104 and 105 select from the key the physical principle which is characteristic in the operation of the device.

KEY

A. Electrons may be ejected from certain substances when heated to a high temperature.
B. An electric current may be produced in a coil whenever the magnetic field through the coil changes.
C. Electrons are emitted from some substances when certain radiation falls upon them.
D. A current-carrying wire has a force acting upon it when placed in a magnetic field.
E. When two different electric conductors are joined and one junction is heated, a flow of electrons takes place in a closed circuit.

104. (1.10) Radio tube. **105.** (1.10) Galvanometer.

106. (1.10) In an operating radio tube the flow of electrons between the filament and the plate is kept proportional to the intensity of a microphone current by means of the

A. rectifier. **B.** trimming condenser.
C. audio amplifier. **D.** gang condenser. **E.** grid.

Items 107 - 112 refer to units of measurement used in electricity which are generally defined in terms of basic principles. For each item select from the key the proper basis for correctly defining the term.

KEY

A. In terms of work (Energy).
B. In terms of rate of working.
C. In terms of the work done on a quantity of electricity.
D. In terms of the field strength under specified conditions.
E. In terms of none of the above.

107. (1.10) Watt. **108.** (1.10) Ohms. **109.** (1.10) Kilowatt-hours.

110. (1.10) Electromagnetic unit of current. **111.** (1.10) Resistivity.

112. (1.10) Volt.

Items 113 - 118 are common units of measurement in electricity. For each item select from the key the term referred to.

KEY

A. Potential difference.
B. Quantity of electricity. **C.** Electric current.
D. Electric power. **E.** None of these.

113. (1.10) Kilowatt-hours. **114.** (1.10) Coulomb. **115.** (1.10) Oersted.

116. (1.10) Volts. **117.** (1.10) Watts. **118.** (1.10) Ampere.

119. (1.10) A radio vacuum tube operates on the principle that

A. radio waves are of higher frequency than light waves.
B. protons will ionize rarefied gases.
C. the current in a circuit is directly proportional to the resistance.
D. Ohm's Law applies to conduction of electricity through gases as well as through solids.
E. a hot wire emits electrons.

120. (1.10) One of the reasons for connecting a charged object to earth with metal is

A. to remove the charge from an object.
B. to prevent the charged object from losing its charge.
C. to use the earth as a conductor.
D. to prevent the accumulation of a static electricity charge.
E. more than one of the above is correct.

121. (1.10) A negatively charged rubber rod is brought *near* a positively-charged electroscope. The result is that

A. the leaves of the electroscope will move farther apart.
B. the rod will lose its charge to the electroscope.
C. positive charges will be pulled away from the leaves.
D. nothing will happen that can be detected without electrical instruments.
E. some of the positive charge on the leaves will be neutralized.

122. (1.10) Which one of the following is *not* one of the effects of the passage of electrons?

A. A spark may be produced if a small air gap is made somewhere in the circuit.
B. Heat may be produced in the conductor.
C. A magnet held in the vicinity of the electrons is acted upon by a magnetic force.
D. The weight of a conductor is increased by the passage of electrons through it.
E. All of the above are effects of the passage of electrons.

123. (1.10) Watts are analogous to which one of the following?

A. Miles per hour. **B.** Cubic inches.
C. Poundals. **D.** Foot-lbs. per second. **E.** Foot-lbs.

124. Which one of the following describes most accurately
(1.10) the concept of an electric current?

A. All conductors of electricity contain positive and negative ions which move when a potential difference exists.
B. Electrons exchange places within the orbits of the same atom when a current flows.
C. Protons become dislodged from the nucleus of an atom and move to re-establish equilibrium.
D. Electrons are dislodged from an atom and electrons from neighboring atoms move in to replace them.
E. Unsatisfied protons pull neighboring electrons into the nucleus of the atom.

125. Lightning rods protect a building during thunderstorms
(1.10) because

A. lightning rods are good insulators.
B. the arrangement acts as a condenser storing electric charges.
C. positive charges leak off the cloud to the rod and neutralize the cloud.
D. electrons pass between the rod and the cloud and neutralize the cloud.
E. they ionize the air between the cloud and the rod.

126. When a hard rubber rod is rubbed with fur, the rubber
(1.10) rod acquires a negative charge. This means that the

A. fur has lost some protons.
B. fur contains only electrons.
C. rubber rod has gained protons.
D. rubber rod has gained neutrons.
E. rubber rod has gained electrons.

127. Which one of these does *not* generate or maintain a
(1.10) potential difference?

A. Light falling on a photoelectric cell.
B. Heating one junction of a thermocouple.
C. Operating a dynamo.
D. Chemical action in a battery.
E. Operating the grid of a radio tube.

128. The concept of energy is stated in various relationships.
(1.10) Which one of these is *incorrect?*

A. Energy is never destroyed by friction.
B. Electricity passing through a resistance is converted to heat energy.
C. Energy is frequently measured in ergs.
D. Increasing the velocity of a body increases its energy.
E. A storage battery awaiting use contains electrical energy.

129. Which one of these is normally connected in series in
(1.10) an electric circuit?

A. Electric light socket. **B.** Transformer.
C. Ammeter. **D.** Electric toaster. **E.** Voltmeter.

130. The volt is used as a unit for measuring
(1.10)

A. potential difference. **B.** quantity of electricity.
C. current. **D.** power. **E.** resistivity.

131. It is better to send 10,000 K.W. of electric power long
(1.10) distances at 10,000 volts rather than at 220 volts because

A. the heating effect is less.
B. the resistance is less at high voltage than at low voltage.
C. the current which can be transmitted increases with increased voltage.
D. insulation is more effective at the higher voltage.
E. the IR drop along the wires is greater the higher the voltage.

Items 132 - 138.

After each item number on the answer sheet, blacken space

A. if the item pertains to static charges.
B. if the item pertains to magnetism.
C. if the item pertains to both.
D. if the item pertains to neither.

132. Unlike (charges or poles) will repel each other.
(1.10)

133. Coulomb's Law.
(1.10)

134. Gasoline trucks drag chains to eliminate them.
(1.10)

135. Unlike (charges or poles) can be independently sep-
(1.10) arated.

136. Can be neutralized by grounding.
(1.10)

137. Electric current in a wire will set up a field of this.
(1.10)

138. In motion will produce electric current.
(1.10)

139. The electric current in a wire essentially consists of
(1.10)

A. positive ions in motion.
B. negative ions in motion.
C. atomic nuclei in motion.
D. electrons in motion.

Item 140 deleted.

141. A tungsten wire of very small diameter heats to incan-
(1.10) descence in a common electric light bulb, because it has a high

A. coefficient of expansion. **B.** thermal conductivity.
C. electrical resistance. **D.** electrical conductivity.

142. In electricity the opposite of resistance is
(1.10)

A. voltage. **B.** amperage. **C.** conductivity.
D. non-conductance.

143. A galvanometer reveals the
(1.10)

A. weight of any atom set free by a given amount of electricity in electrolysis.
B. number of watts consumed by an electric appliance.
C. charge on a moving electron.
D. presence of a magnetic field produced by a current flowing through a wire.

144. In Chicago much electricity is obtained
(1.10)

A. by burning waste. **B.** by burning coal.
C. from waterways. **D.** from lake tides.

145. Alternating current is used because
(1.10)

A. most appliances built have to use it.
B. it is more energetic than direct current.
C. it is cheaper to transmit than direct current.
D. it is less dangerous than direct current.

146. Resistance is measured in
(1.10)

A. dynes. **B.** volts. **C.** ohms. **D.** amperes.

147. The voltmeter measures
(1.10)

A. current. **B.** potential difference. **C.** resistance.
D. electricity consumed.

148. The ammeter measures
(1.10)

A. current. **B.** voltage. **C.** charge. **D.** resistance.

149. Quantity of electricity is expressed in
(1.10)

A. volts. **B.** amperes. **C.** coulombs. **D.** ohms.

150. The lead storage battery is so called because
(1.10)

A. it stores up lead during discharge.
B. it uses up the lead stored in the battery during charge.
C. it stores electricity between the plates.
D. chemicals consumed during discharge are reproduced when the battery is charged.

151. The voltaic pile constituted
(1.10)

A. the initial development of the atom bomb.
B. a device for slowing up neutrons.
C. the first battery. **D.** the first D.C. motor.

Items 152 - 159.

After each item number on the answer sheet, blacken space

A. if the item is true only of direct current.
B. if the item is true only of alternating current.
C. if the item is true of both types of current.
D. if the item is true of neither type of current.

152. This type of current must be used in electroplating.
(1.10)

153. It will operate a motor which has no rings or brushes.
(1.10)

154. This type of current cannot be used to produce a magnetic field.
(1.10)

155. It consists of electrons in motion.
(1.10)

156. This type of current may be transmitted long distances with less loss.
(1.10)

157. The voltage of this type of current can be more readily raised or lowered by means of a transformer.
(1.10)

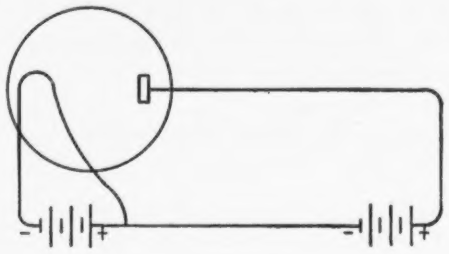
158. This type of current will operate an electric heater.
(1.10)

159 This type of current is obtained when electrons are emitted from a hot filament.
(1.10)

160. The three-electrode tube has
(1.10)

A. a galvanometer between the plate and the filament.
B. an anode between the filament and the plate.
C. a cathode between the plate and the galvanometer.
D. a grid between the plate and the filament.

Statement: A filament in an evacuated tube is heated by an electric current from a battery while a plate or electrode in the tube is connected with the positive side of another battery.



161. *Effect:*
(1.10)

A. The filament is oxidized.
B. Electrons travel from the filament to the electrode.
C. The gas in the tube becomes ionized.
D. Positive rays travel from the filament to the electrode.
E. Electrons travel from the external electrode to the filament.

162. *Cause:*
(1.10)

A. Metals will emit electrons when heated.
B. Metals will emit electrons when activated by light.
C. Ionized air will conduct electricity.
D. Electrons will not travel in a vacuum.
E. Complete circuits are necessary for transmission of an electron current.

Statement: Two dissimilar metal electrodes are placed in a solution of an electrolyte. The external ends of the electrodes are connected to the terminals of a galvanometer.

163. *Effect:*
(1.10)

A. The galvanometer will oscillate.
B. The electrolyte will dissolve.
C. The metallic electrodes will dissolve.
D. A current will flow.
E. The solution will decompose due to electrolysis.

164. *Cause:*
(1.30)

A. The electrolyte acts on the solvent.
B. The solution acts on the galvanometer.
C. Electrons are gained at one electrode and lost at the other.
D. The electrodes react with each other.
E. The galvanometer furnishes the current.

165. The electrochemical equivalent is measured in
(1.10)

A. grams per coulomb. **B.** $cm.^3$ per ampere.
C. terms of atomic weight divided by the valence.
D. calories per gram. **E.** watts.

166. When electricity is passed through a resistance, the energy is expended as
(1.10)

A. amperes. **B.** calories. **C.** coulombs.
D. volts. **E.** ohms.

For items 167 - 172 select from the key the condition most closely related to each item.

KEY

A. Neutral. B. Positively charged.
C. Negatively charged. D. Magnetic.
E. Two of the above.

167. (1.10) An electroscope after being charged by conduction with a glass rod.

168. (1.10) An electroscope after being charged permanently by induction with a rubber rod.

169. (1.10) An ion collecting at an anode.

170. (1.10) An atom.

171. (1.10) A neutron.

172. (1.10) A proton.

173. (1.10) In electroplating silver, the silver is deposited on the

A. cathode. **B.** nearer electrode. **C.** larger electrode.
D. positive electrode. **E.** anode.

174. (1.10) If an insulated hollow metal sphere is given a positive charge,

- **A.** the charges will be uniformly distributed throughout its volume.
- **B.** positive charges will have been added to it.
- **C.** no charge will be found inside the sphere.
- **D.** it will immediately disappear.
- **E.** it will contain no electrons.

175. (1.10) These all refer to the same concept in electricity *except*

A. amperes. **B.** a flow of electrons.
C. the time rate of flow of electricity.
D. potential difference. **E.** coulombs per second.

Items 176 - 182 refer to units or terms applied to fundamental concepts in electricity. For each item select from the key the most closely related concept.

KEY

A. Potential difference. **B.** Quantity of electricity.
C. Electric current. **D.** Electric power.
E. Electrical resistance.

176. (1.10) IR drop.

177. (1.10) Watts.

178. (1.10) Coulomb.

179. (1.10) Ohm.

180. (1.10) Ampere.

181. (1.10) Volt.

182. (1.10) Electromotive force.

183. (1.10) A consumer of electrical energy pays for

A. ampere-hours. **B.** volts. **C.** volt-amperes.
D. kilowatts. **E.** kilowatt-hours.

184. (1.10) An electric field about an isolated positively charged sphere is usually considered as

- **A.** lines of force curving like those from the N pole of a magnet.
- **B.** non-existent unless there is an equal negative charge on the sphere.
- **C.** a field of force with lines perpendicular to the surface.
- **D.** possible only if the sphere is metallic.
- **E.** a result of having no electrons in the sphere.

Items 185 - 191. Indicate the most closely related word or phrase from the key at the right.

		Disc.	Diff.
185. (1.10)	Found only on the surface of a metallic body.	.26	37
186. (1.10)	Cannot pass through a sheet of soft iron.	.30	37
187. (1.10)	Polarity.	Neg.	12
188. (1.10)	Positive and negative components may be indefinitely separated.	0	11
189. (1.10)	Effect may be transferred to other bodies by induction.	.16	28
190. (1.10)	Possible to insulate.	.35	15
191. (1.10)	Due to transfer of electrons from one part to another, of the body.	.20	23

KEY

- **A.** static electricity.
- **B.** magnetism.
- **C.** current electricity.
- **D.** two of the above.
- **E.** three of the above.

Items 192 - 196 concern electricity and magnetism. Select from the key the response which correctly fills the blank space.

KEY

A. Static electricity. **B.** Magnetism.
C. Current electricity. **D.** Electromagnetic.
E. Two of the above.

192. (1.10) Radio waves are________.

193. (1.10) ________cannot pass through a sheet of soft iron.

194. (1.10) ________may be transferred by induction.

195. (1.10) ________is due to the transfer of electrons from one part of the body to another.

196. (1.10) ________resides on the surface of a body.

197. (1.10) Which one of these terms is most unlike the others?

A. Electromotive force. **B.** IR drop.
C. Difference in potential. **D.** Current. **E.** Voltage.

198. (1.10) In a wattmeter there are

- **A.** a fixed coil and a movable permanent magnet.
- **B.** a fixed permanent magnet and a movable coil.
- **C.** two fixed coils.
- **D.** a fixed coil and a movable coil.
- **E.** two movable coils.

199. (1.10) The plates of a simple voltaic cell should be

- **A.** of different material.
- **B.** not more than 19 sq. cms. in area.
- **C.** more than one mm. thick.
- **D.** other than flat in shape. **E.** rectangular in shape.

200. (1.10) The impedance of an A.C. circuit is

A. volts divided by amperes.
B. volts divided by ohms.
C. henries multiplied by amperes.
D. henries divided by ohms.
E. farads divided by amperes.

201. (1.10) A circuit containing resistance only is connected to 110-volt 60-cycle mains. If a capacitor is connected in series the current

A. lags behind the e.m.f.
B. is in phase with the e.m.f. **C.** is decreased.
D. is increased. **E.** remains constant.

202. (1.10) A circuit containing resistance only is connected to 100-volt 60-cycle mains. If an inductance is connected in series the current

A. leads the e.m.f. **B.** is in phase with the e.m.f.
C. is decreased. **D.** is increased.
E. remains constant.

203. (1.10) A vacuum tube with a filament and a plate only is used as

A. a rectifier. **B.** an amplifier. **C.** a modulator.
D. an oscillator. **E.** an alternator.

204. (1.10) In an electrolyte the positive ions are

A. attracted by the positive plate.
B. attracted by the negative plate.
C. repelled by both plates.
D. not affected by the relative potentials of the plates.
E. attracted by both plates.

205. (1.10) The e.m.f. of a cell is affected primarily by

A. the materials of the plates.
B. the kind of electrolyte.
C. the size of the plates.
D. the distance between the plates.
E. the roughness of the plates.

206. (1.10) The electrochemical equivalent of silver is 0.001118. This means

A. one coulomb deposits 0.001118 gram of silver.
B. 0.001118 coulomb deposits one gram of silver.
C. one ampere deposits 0.001118 gram of silver.
D. 0.001118 ampere deposits one gram of silver.
E. one atom of silver has a charge of 0.001118 coulomb.

207. (1.10) A transformer may be used

A. to convert an alternating current and voltage to a larger current at a higher voltage.
B. to transform alternating current into direct current.
C. to decrease an alternating voltage and increase the current.
D. to step up the voltage of battery.
E. to transform an alternating voltage at one frequency to an alternating voltage at another frequency.

208. (1.10) A galvanometer coil has a resistance of 100 ohms and will carry a current of only 0.10 ampere. This galvanometer may be made into a voltmeter to read 20 volts by

A. connecting a large resistance across the terminals.
B. connecting a small resistance across the terminals.
C. placing a large resistance in series.
D. placing a small resistance in series.

209. (1.10) A galvanometer coil has a resistance of 100 ohms and will carry a current of only 0.10 ampere. This galvanometer may be made into an ammeter to read 20 amps. by

A. connecting a large resistance across the terminals.
B. connecting a small resistance across the terminals..
C. placing a large resistance in series.
D. placing a small resistance in series.

210. (1.10) Alternating current is not suitable for

A. running electric motors.
B. heating electric toasters.
C. transmitting electric power.
D. charging storage batteries. **E.** operating radios.

211. (1.10) Alternating currents can be transformed to direct currents by

A. an A.C. transformer.
B. a capacity and inductance in series.
C. a resistance and inductance in parallel.
D. a synchronous induction motor.
E. a motor-generator set.

212. (1.10) The purpose of the grid in an ordinary vacuum tube is to

A. control the filament-plate current.
B. supply the total tube voltage.
C. cause electron emission from the filament.
D. complete the tube circuit.
E. supply electrons for the operation of the tube.

213. (1.10) Graphite

A. is a good conductor of electricity because of the electrovalent linkages it contains.
B. is a good lubricant because it liquefies under pressure.
C. is frequently used as a reducing agent in metallurgy.
D. is produced when any form of carbon is subjected to a very high temperature out of contact with air.
E. is a commercial source of benzene and toluene.

214. (1.10) In the lead storage cell

A. the action, unlike that in the dry cell, is not reversible.
B. the specific gravity of the electrolyte increases as the cell is discharged.
C. as designed, the cell gives a large voltage, but a small amperage.
D. when discharging, the same substance forms on both poles.
E. when fully charged, no more charging current can be passed through the cell.

215. (1.10) Static electricity is

A. the same as magnetism. **B.** a magnetic effect.
C. found only on magnets. **D.** out of date.
E. quite distinct from magnetism.

216. (1.10) Assuming that each of the following can be connected to the terminals of a 60-cycle 110-volt alternating current line without burning out a 10-ampere fuse in series, which one could probably not be so connected to a 110-volt direct current line?

A. a 50-watt tungsten light. **B.** a mica condenser.
C. an electric flatiron.
D. the primary of a transformer.

217. A step-down transformer is used to
(1.10)

A. increase resistance.
B. change direct to alternating current.
C. change alternating to direct current.
D. change high-voltage power to low-voltage.
E. change low-voltage power to high-voltage.

218. The electrical energy expended in causing a current to
(1.10) flow through a resistance appears as

A. volts. **B.** amperes. **C.** sound.
D. mechanical work. **E.** heat.

219. If the current is at right angles to this paper, the
(1.10) magnetic field in the plane of the paper would be represented by

A. a set of parallel straight lines. **B.** a spiral.
C. an ellipse. **D.** a series of concentric circles.
E. that of a bar magnet.

220. A non-conductor of electricity is a material
(1.10)

A. which contains no electrons.
B. through which electrons do not flow freely.
C. which always has more electrons than protons on its surface.
D. which cannot be melted.

221. A wheatstone bridge is primarily an instrument for
(1.10) comparing

A. e.m.f.s. **B.** currents. **C.** power.
D. resistances. **E.** potential difference.

222. In a direct-current series motor the armature current is
(1.10)

A. the same as the field current.
B. smaller than the field current.
C. larger than the field current. **D.** zero.
E. independent of the field current.

223. In lead storage cells the specific gravity of the solu-
(1.10) tion increases if the cell is

A. being filled with distilled water.
B. being disconnected. **C.** left alone.
D. being discharged. **E.** being charged.

224. From a practical point of view the field of a bar magnet
(1.10) is the

A. space between the poles. **B.** volume of the magnet.
C. region in which its force may be detected.
D. plane of the magnet. **E.** axis of the magnet.

225. To make an uncharged body have a negative charge
(1.10) we must

A. add some atoms. **B.** take away some atoms.
C. give it some electrons.
D. take away some electrons.
E. put down a minus sign.

226. To give a positive charge to an uncharged conductor
(1.10) we must

A. rub it with silk. **B.** rub it with flannel.
C. add some electrons. **D.** remove some electrons.
E. touch it to an electric circuit.

227. A potentiometer is primarily an instrument for compar-
(1.10) ing

A. currents. **B.** power. **C.** resistances.
D. potential differences. **E.** capacities.

228. A conductor of electricity is a material
(1.10)

A. which contains more electrons than protons.
B. which is a solid except at very high temperatures.
C. which is opaque to visible light.
D. whose electrons are all on the surface.
E. through which electrons move freely.

229. The electromotive force of a simple voltaic cell de-
(1.10) pends primarily upon

A. the size of the plates.
B. the distance between the plates.
C. the material of the electrolyte.
D. the material of the plates.
E. the current flowing through the cell.

230. The meter installed in your house by the electric power
(1.10) company is

A. an ammeter. **B.** a voltmeter. **C.** a wattmeter.
D. a watt-hour meter. **E.** an ohmmeter.

231. Select the correct statement or statements among those
(1.10) below.

a. Insulators do not contain an appreciable number of free electrons.
b. If 10 coulombs of electricity are transmitted through a light bulb in 1 second, the current is 10 amperes.
c. The electric current in a wire is due to a drift of negative charges through the wire.

The correct selection includes

A. only a. **B.** only b. **C.** only c.
D. only a and c. **E.** a, b, and c.

232. The property which, varying for different kinds of elec-
(1.10) tromagnetic radiation, serves best to distinguish them and to explain the differences in their properties is

A. frequency. **B.** refrangibility. **C.** reflexibility.
D. velocity in a material medium.
E. visibility or invisibility.

233. That property whose numerical identity for all forms
(1.10) of radiation supports the assumption that the underlying process is the same for all of them, is

A. refrangibility. **B.** velocity in a vacuum.
C. frequency. **D.** wave-length. **E.** energy.

234. The principle that lines of electric force begin and end
(1.10) only upon electric charges is a consequence of

A. the principle of the conservation of energy.
B. the law of the conservation of charge.
C. the fact that electric attractions and repulsions vary inversely with the square of the distance between charges.
D. the principle that charges of unlike sign attract one another, since such attraction is represented by lines of force going from one charge to the other.
E. the definition of lines of force.

235. In copper plating, if the anode is made twice as large
(1.22a)

A. the plating time will be made double.
B. twice as much copper will be deposited in a given time.
C. the plating rate will not change.
D. the resistance of the cell will change.
E. a greater current will flow.

236. (1.22a) Electricity is sold by the kilowatt hour. We can calculate the number of kilowatt hours by means of the following formula:

A. $\frac{\text{volts} \times \text{hours}}{\text{amperes} \times 1000}$.
B. $\frac{\text{volts} \times \text{hours} \times 1000}{\text{amperes}}$.
C. volts × amperes × hours × 1000.
D. $\frac{\text{volts} \times \text{amperes}}{\text{hours} \times 1000}$.
E. $\frac{\text{volts} \times \text{amperes} \times \text{hours}}{1000}$.

For items 237 - 241 select from the key the response which will correctly fill the blank space in the statement of each item.

KEY

A. is greater than. **B.** is less than.
C. is the same as.

237. (1.22a) If the resistance wire of an electric toaster is shortened, the resistance of the toaster________its former value.

238. (1.22a) If a resistance wire of the same material but larger in diameter is substituted for the original, the resistance ________before.

239. (1.22a) A toaster with a resistance of 35 ohms and a flat-iron with a resistance of 15 ohms are connected in parallel to a household circuit. The heat liberated by the flat-iron________the toaster.

240. (1.10) The specific gravity of kerosene________that of water.

241. (1.10) In a vacuum, the acceleration of a freely falling 5 lb. block of gold________the acceleration of a freely falling 10 lb. block of aluminum.

242. (1.22a) The amount of zinc consumed in a gravity cell is proportional to

A. the number of coulombs which pass through the cell.
B. the size of the zinc plate.
C. the potential difference between the plates.
D. the square of the magnitude of the current used.
E. the polarization of the plates.

243. (1.22a) To decrease the resonant frequency of an A.C. circuit by one-half

A. the resistance is doubled.
B. the inductance is doubled.
C. the capacity is doubled.
D. the inductance and capacity are doubled.
E. the resistance, inductance, and capacity are doubled.

244. (1.22a) If, in a parallel plate condenser, both the area of the plates and the distance between them is doubled, the capacity will be

A. doubled. **B.** halved. **C.** unchanged.
D. tripled. **E.** quadrupled.

245. (1.22a) A certain wire has a resistance R. Another wire, made of the same material with half the length and half the diameter of the first wire, has a resistance of

A. R/4. **B.** R/2. **C.** R. **D.** 2R. **E.** 4R.

246. (1.22a) The maximum kinetic energy of photoelectrons from an illuminated surface increases

A. when the light intensity increases.
B. when the light intensity decreases.
C. when the light frequency increases.
D. when the light frequency decreases.
E. independently of light intensity and frequency.

247. (1.22a) The amperage of a primary cell depends upon

A. the amount of chemical action going on, and that, in turn, upon the surface area of the poles.
B. the concentration of the solutions around the poles.
C. the nature of the membrane.
D. the electrostatic stress.
E. the prevailing humidity of the atmosphere.

248. (1.22a) Increasing the current in the filament of a vacuum tube

A. ejects more electrons from the grid.
B. raises the grid voltage.
C. raises the plate voltage.
D. ejects fewer electrons from the filament.
E. ejects more electrons from the filament.

249. (1.22a) According to the law of Faraday, the weights of different elements released at the poles by the passage through the solution of the same number of coulombs of electricity are proportional to

A. the atomic weights of the elements.
B. the product of the atomic weight by the combining weight.
C. the atomic numbers.
D. the quotient of the atomic weight divided by the valence.
E. the positive charge of the nucleus.

250. (1.22a) A wire is placed with its length perpendicular to a known magnetic field. When a current is sent through it, the force exerted on the wire

A. is unpredictable as to direction.
B. depends only on the strength of the magnetic field.
C. is only a convention, no force is really exerted.
D. depends for its direction on the direction of the current and that of the magnetic field.
E. decreases rapidly as the current is increased.

251. (1.22a) The quantity of heat developed per minute in a coil of fixed resistance is

A. proportional to the current of the coil.
B. proportional to the square of the current of the coil.
C. proportional to the square of the resistance of the coil.
D. inversely proportional to the current in the coil.

252. (1.25) To measure the current through a lamp we often

A. put an ammeter in parallel with the lamp.
B. put a voltmeter in series with it.
C. put an ammeter in series with it.
D. use a Wheatstone bridge. **E.** use a wattmeter.

253. (1.22a) The quantity of heat developed in a coil of fixed resistance is

A. proportional to the potential at the terminals of the coil.
B. proportional to the current in the coil.

C. proportional to the square of the potential difference at the terminals of the coil.
D. proportional to the length of wire in the coil.
E. inversely proportional to the current in the coil.

254. (1.22a) The capacity of an electrical condenser is

A. proportional to the quantity of electricity on the plates.
B. directly proportional to the effective area of the plates.
C. independent of the material between the plates.
D. proportional to the potential difference between the plates.
E. proportional to the distance between the plates.

255. (1.22a) In copper plating the weight of copper deposited is proportional to

A. the concentration of the solution.
B. the size of the anode.
C. the density of the current stream.
D. the quantity of electricity which passes.
E. the size of the cathode.

Items 256 - 258. Evaluate the statements according to the key.

KEY

A. A scientific law.
B. A theoretical and unproved idea advanced to explain or account for observed experimental results.
C. A correct definition.
D. A statement in contradiction to a law, accepted theory or definition.

256. (1.23) Like electrical charges repel each other.

257. (1.23) Heat developed in a conductor is proportional to the square of the current flowing in the conductor.

258. (1.23) The kind of a charge found on a glass rod after rubbing it with silk is called positive.

Items 259 - 262.

KEY

A. A fact by observation. **B.** A fact by definition.
C. A conceptual scheme.
D. A deduction from the conceptual scheme.
E. None of the above.

259. (1.23) When a magnetic needle is placed near a wire carrying an electric current, the needle comes to rest in a position at right angles to the wire.

260. (1.23) Electricity consists of tiny invisible particles.

261. (1.23) The tiny invisible particles are intimately associated with atoms.

262. (1.23) The atom is held together by the attraction between the positive nucleus and the negative electrons encircling it.

263. (1.25) A galvanometer coil has a resistance of 100 ohms and will carry a current of only 0.01 ampere. This galvanometer may be made into a voltmeter to read 20 volts by

A. placing a 1900 ohm resistance in series.
B. placing a 20,000 ohm resistance in series.
C. connecting a 19.9 ohm resistance across the terminals.
D. connecting a 20,000 ohm resistance across the terminals.

264. (1.25) A galvanometer coil has a resistance of 100 ohms and will carry a current of only 0.01 ampere. This galvanometer may be made into an ammeter to read 0.1 amp by

A. placing a 100.1 ohm resistance in series.
B. placing a 9.9 ohm resistance in series.
C. connecting a 100.1 ohm resistance across the terminals.
D. connecting an 11.1 ohm resistance across the terminals.

265. (1.25) The current within a battery that is connected to an external circuit may be found by dividing

A. the e.m.f. of the battery by the internal resistance of the battery.
B. the e.m.f. of the battery by the total resistance of the circuit.
C. the terminal voltage of the battery by the internal resistance of the battery.
D. the terminal voltage of the battery by the total resistance of the circuit.
E. the power dissipated in the battery by the terminal voltage.

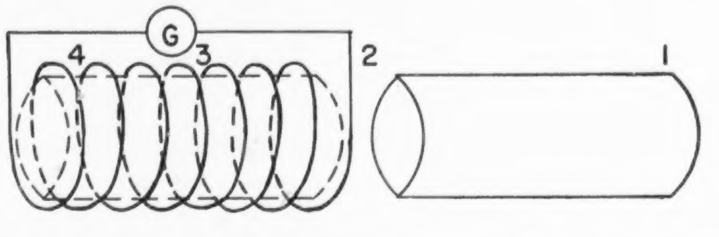
266. (1.25) To increase the range of a D.C. ammeter it is equipped with

A. a high resistance in series.
B. a low resistance in series.
C. a high-resistance shunt.
D. a low-resistance shunt. **E.** none of these.

267. (1.25) The magnitude of the earth's magnetic field could be given by specifying

A. the declination and the dip.
B. the declination and the horizontal component.
C. the declination and the vertical component.
D. the dip and the vertical component.

Items 268 - 270 refer to the following diagram.



268. (1.30) The greatest deflection would occur when the iron core is

A. at rest outside the coil.
B. entering the coil at a given rate.
C. approaching the center of the coil at the same rate.
D. at rest within the coil.

269. (1.10) The diagram illustrates a principle that is applied in

A. generators. **B.** door bells. **C.** condensers.
D. fluorescent lights. **E.** none of the above.

270. (1.10) From the historical point of view, the man most closely connected with the above principle was

A. Faraday. **B.** Ampere. **C.** Ohm.
D. Oersted. **E.** Henry.

271. A conductor consisting of a long straight rod cuts a
(1.30) magnetic field. Which one of the following statements is *false?*

- **A.** The faster the motion of the rod, the greater the induced voltage.
- **B.** A continuous current flows from one end of the rod to the other.
- **C.** The stronger the magnet, the greater the induced voltage at any given rate of cutting lines for force.
- **D.** The effect is the same whether the magnet is a permanent magnet or an electromagnet.
- **E.** None of the above.

272. Which of these is true when a coil of wire is rotated in
(1.30) the magnetic field between a north and south pole?

- **A.** The current is a maximum when the plane of the coil is parallel to the magnetic field.
- **B.** The current is greatest when the greatest number of lines of force pass through the coil.
- **C.** The current is never zero.
- **D.** The current in the coil is constant and in the same direction at all times.
- **E.** The current varies in magnitude but has a constant direction at all times.

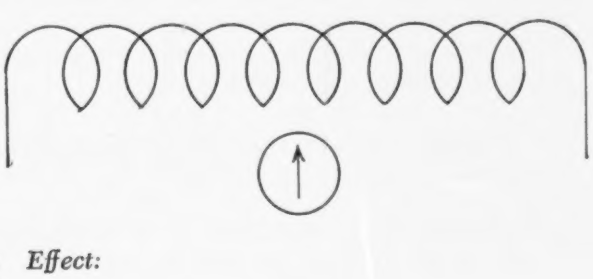
273. Which of the following combinations of things and cir-
(1.30) cumstances cannot be made to produce an electric current?

- **A.** Two dissimilar metals joined at the ends and the ends kept at different temperatures.
- **B.** Two dissimilar metals placed in a solution of an acid.
- **C.** A stationary coil of wire and a stationary magnet.
- **D.** A movable coil of wire and the earth's magnetic field.
- **E.** A stationary coil of wire and a movable magnet.

274. An electrical current may be produced in a wire (the
(1.30) ends of which are to be joined to complete the circuit) in *all* ways *but*

- **A.** moving a magnet in a coil of wire.
- **B.** moving a coil of wire in a magnetic field.
- **C.** making an expanding electromagnetic field cut across a coil of the wire.
- **D.** placing the wire in which the current is to be produced alongside a wire carrying an alternating current.
- **E.** winding the wire in which the current is to be produced around a wire carrying a direct current.

Statement: A compass is placed near a coil of wire and a current of electricity is then passed through the coil, as shown in the diagram.



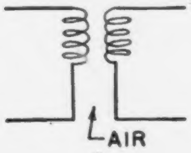
275. *Effect:*
(1.30)

- **A.** The current stops.
- **B.** The coil of wire assumes a north-south direction.
- **C.** The needle parallels the coil.
- **D.** The compass needle is magnetized.
- **E.** The compass itself assumes a north-south direction.

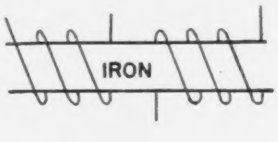
276. *Cause:*
(1.30)

- **A.** The compass exerts an electrical force on the coil.
- **B.** Current passing through a wire creates a magnetic field about the wire.
- **C.** The copper in the wire deflects the compass needle.
- **D.** Since the compass needle is demagnetized, it assumes the same direction as the current.
- **E.** The magnetism in the compass needle stops the current from flowing in the wire.

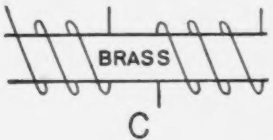
277. Which of the following diagrams as represented would make the best transformer?



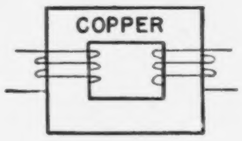
A



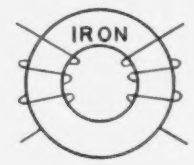
B



C

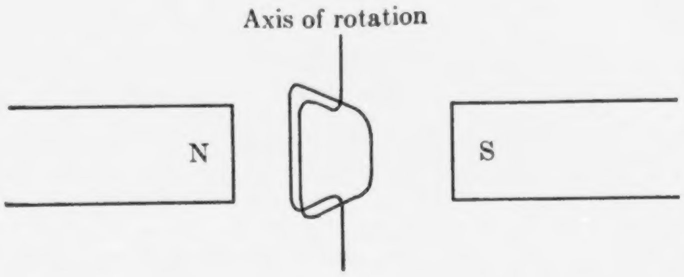


D



E

Statement: A coil of wire is rotated between the poles of a magnet.



278. *Effect:*
(1.30)

- **A.** The magnet is demagnetized.
- **B.** The electrons in the wire are forced to move along the wire.
- **C.** The electrons in the magnet stop revolving.
- **D.** The electrons in the wire stop revolving.
- **E.** The copper in the wire becomes magnetic.

279. *Cause:*
(1.30)

- **A.** Lines of force are cut by a conductor.
- **B.** Active metals when heated, emit electrons.
- **C.** The opposing magnetic field created in the coil reduces the strength of the pole magnets.
- **D.** All of the electrons flow in the wire so that there is none left to revolve.
- **E.** The electrons leave the magnet and flow in the wire.

280. A bar of soft iron can best be kept from becoming
(1.30) magnetized by storing it

- **A.** inside a coil of copper wire.
- **B.** coated with heavy varnish.
- **C.** in but not touching an iron box.
- **D.** in a vertical position.
- **E.** wrapped in any non-magnetic material.

281. (1.30) Which of the following would provide the best test to determine whether a metal bar is a magnet?

A. Determine whether the bar is attracted by a magnet.
B. Determine whether the bar is repelled by a magnet.
C. Analyze the bar to see if it contains iron.
D. Determine whether the bar has been recently heated red hot.
E. Determine whether the bar has been near magnets.

282. (1.30) The force of attraction between unlike magnet poles is

A. directly proportional to the distance between them.
B. inversely proportional to the distance between them.
C. directly proportional to the square of the distance between them.
D. inversely proportional to the square of the distance between them.
E. independent of the distance between them.

283. (1.30) The statement that "A magnet attracts nothing except another magnet," is

A. not correct since some unmagnetized metals are attracted by magnets.
B. correct because all metals can be at least partially magnetized.
C. not correct because some metals which are attracted by magnets cannot be magnetized.
D. in agreement with the phenomenon of magnetization by induction.
E. dependent upon the nature of the magnet.

284. (1.30) In the magnetization of an iron object all of the following statements are accurate *except*

A. the phenomenon of magnetism is most pronounced near the ends.
B. the degree of magnetization attained can be affected by temperature.
C. the degree of magnetization can be affected by jarring or hammering.
D. it cannot be predicted which end shall be the north seeking end.
E. the intensity of magnetization cannot be continued beyond a maximum amount.

285. (1.30) Which of the following represents a difference between the behavior of magnetic poles and electrical charges (i.e., which is not true of both)?

A. Unlike attract, likes repel.
B. Can act at a distance.
C. Can be moved along a conductor.
D. Exerted force becomes less as the distance between them increases.
E. The phenomenon appears in more than one element.

286. (1.30) A boy was given his grandfather's gold watch. Upon opening it he discovered an iron case inside of the gold exterior. The most probable purpose of the iron covering was

A. to add strength to the softer gold exterior.
B. to make it water tight.
C. to shield it from magnetism.
D. to deaden the sound of ticking.
E. to act as a shock absorber if dropped.

287. (1.30) A magnet broken into one hundred pieces yields

A. 200 magnets. **B.** 100 magnets.
C. 50 magnets. **D.** no magnets.

Statement: A piece of steel is stroked a number of times in one direction by the north pole of a magnet.

288. (1.30) *Effect:*

A. The magnet loses its magnetism.
B. The north pole of the magnet becomes a south pole.
C. The piece of steel can not conduct an electric current.
D. The steel assumes an east-west direction.
E. The piece of steel becomes a magnet.

289. (1.30) *Cause:*

A. The steel molecules become magnetized.
B. The molecules in the steel line up in uniform fashion.
C. The molecules in the steel become hot.
D. The magnet itself is broken in half.
E. The lines of force in earth causes the steel to become magnetic.

Items 290 - 305.

After each item number on the answer sheet, blacken space

A. if the blanks can be correctly filled by "electric charge(s)" only.
B. if the blanks can be correctly filled by "magnetic pole(s)" only
C. if the blanks can be correctly filled by either term.
D. if the blanks can be correctly filled by neither term.

290. (1.10) Like________repel each other; unlike________attract each other.

291. (1.10) ________are attracted or repelled by a stationary electric charge.

292. (1.10) A moving electric charge exerts a force on________.

293. (1.10) ________are produced by gain or loss of electrons.

294. (1.10) When one________is produced, another of the opposite kind must be produced also.

295. (1.10) When two equal but unlike________are connected by a copper wire, both disappear.

296. (1.10) When a piece of metal having two opposite________is broken, two new ones are formed.

297. (1.10) ________are produced by orientation of many atoms in a particular direction.

298. (1.10) If a piece of metal has one________, it must have another of the opposite kind also.

299. (1.10) The region around one or more________is known as a field.

300. (1.10) When a stream of electrons passes through a coil of wire, the ends of the coil are________.

301. (1.10) "Declination," "dip," "agonic lines" refer to the effect of the________of the earth on small pieces of metal.

302. (1.10) The force of attraction between two opposite________is inversely proportional to the square of the distance between them.

303. (1.10) Ions are atoms or groups of atoms bearing________.

304. (1.10) When a piece of metal is heated, its________, if it has any, become larger.

305. A moving magnet exerts no force on nearby________.
(1.10)

306. A porous container which holds zinc sulfate solution in which a zinc plate is immersed, is in turn immersed in a copper sulfate solution which also has a copper plate dipped in it. The zinc plate and the copper plate are connected by a wire.
(1.30)

- **A.** Electrons flow from the zinc plate through the wire to the copper plate.
- **B.** Electrons flow from the copper plate through the wire to the zinc plate.
- **C.** Zinc ions are formed in the zinc sulfate solution and copper ions are formed in the copper sulfate solution.
- **D.** Nothing happens.
- **E.** Copper displaces the zinc from the zinc sulfate solution.

307. In a simple cell with Zn and Cu electrodes placed in a solution of $CuSO_4$
(1.30)

- **A.** Cu atoms at the Cu electrode gain electrons.
- **B.** the Zn electrode becomes positively charged.
- **C.** electrons flow from the Zn to the Cu in the solution.
- **D.** Zn is deposited on the Cu electrode.
- **E.** Zn atoms from the Zn electrode become Zn ions.

308. Of the following, the potential difference across the terminals of a primary cell or a discharging secondary cell depends mostly upon
(1.30)

- **A.** the quantity of electrolyte (liquid) used.
- **B.** how close together the cathode and anode are placed.
- **C.** the kind of substances used as positive and negative poles.
- **D.** the area of the substance exposed to electrolytic action.
- **E.** the temperature under which the cell is operated.

309. Which of the following is relatively *unimportant* in the installation of lightning rods?
(1.30)

- **A.** The rods should have sharp points.
- **B.** The rods should be made of good conducting materials.
- **C.** The rods should have a good ground.
- **D.** The rods should be at least five feet long.
- **E.** The number of rods required varies with the size of the building.

310. The resistance of an electric heater can be determined if one knows only the
(1.30)

- **A.** voltage across its terminals.
- **B.** current through it.
- **C.** number of watts it requires.
- **D.** diameter and length of wire in the heating element.
- **E.** power rating and the voltage across its terminals.

311. Electric power is transmitted across country at high voltage because
(1.30)

- **A.** as voltage increases resistance decreases.
- **B.** the current may be direct instead of alternating.
- **C.** less difficulties are encountered with insulation.
- **D.** there is less self induction in the wires.
- **E.** the higher the voltage the lower the current necessary.

312. The resistance of a circuit carrying an electric current may be raised by
(1.30)

- **A.** shortening the length of the circuit.
- **B.** coiling a part of the wire.
- **C.** cooling the wire of the circuit.
- **D.** substituting a wire of the same material but of smaller cross section.
- **E.** substituting copper wire for iron wire.

313. During a thunderstorm the safest place to stay (of those mentioned below) is
(1.30)

- **A.** in the middle of a large open level field.
- **B.** under a tree in the middle of a large open field.
- **C.** in the bathtub. **D.** in a wooden building.
- **E.** inside a trailer made entirely of steel.

314. In the simple cell made up of a zinc and a copper electrode in a copper sulphate solution
(1.30)

- **A.** copper atoms from the copper electrode are changed to copper ions as they go into solution.
- **B.** the zinc electrode becomes positively charged.
- **C.** the copper electrode is used up.
- **D.** electrical energy is transformed into chemical energy.
- **E.** electrons are left behind on the zinc electrode when atoms of zinc become zinc ions.

315. Of the following principle the one that is first involved in the radio receiver's transformation of electromagnetic waves into audible waves is that of
(1.30)

A. detection. **B.** amplification. **C.** rectification.
D. resonance. **E.** modulation.

Items 316 - 320.

KEY

- **A.** The fluid theory of electricity.
- **B.** The particulate theory of electricity.
- **C.** Both A and B. **D.** Neither A nor B.

316. Build up pressure. **317.** Has a fixed shape.
(1.30) (1.30)

318. Has mass. **319.** Evidence of fixed discrete units.
(1.30) (1.30)

320. Can be infinitely subdivided.
(1.30)

321. By *induction*, a permanent charge may be fixed upon a metallic object which is mounted upon a glass support for insulation, by means of which of the following sequences of events?
(1.30)

- **A** Bring the charged body close to the object to be charged, ground the object, remove the initially-charged body, remove the ground connection.
- **B.** Ground the object, bring the charged body close to the object to be charged.
- **C.** Bring the charged body close to the object to be charged, ground the object, remove the ground connection, remove the initially charged body.
- **D.** Ground the object, remove the ground, bring the charged body close to the object to be charged, remove the initially charged body.
- **E.** Bring the charged body close to the object to be charged, remove the initially charged body, ground the object, remove the ground connection.

322. Two pith balls, both of which have been touched by a Lucite rod which had been rubbed with wool, will
(1.30)

- **A.** attract each other and be repelled by the Lucite rod.
- **B.** repel each other and be attracted by the Lucite rod.
- **C.** repel each other and be repelled by the Lucite rod.
- **D.** attract each other and be attracted by the Lucite rod.
- **E.** attract each other and be repelled by a glass rod which has been rubbed with silk.

323. (1.30) Ohm's law states that the current varies directly with the

A. resistance and inversely as the voltage.
B. voltage and inversely as the resistance.
C. resistance and inversely as the potential.
D. voltage and inversely as the square of the distance.

324. (1.30) The e.m.f. set up in a conductor moving perpendicularly to the lines of a given magnetic field

A. depends only on the speed of the conductor.
B. depends upon the resistance of the conductor.
C. depends upon the direction of the field.
D. depends upon the material of the conductor.
E. depends upon the current in the conductor.

325. (1.30) The action of an induction coil depends upon

A. abrupt changes in magnetic fields.
B. exactly the same effects as are present in an electric generator.
C. an alternating current in the primary coils.
D. absence of inductance in the primary coils.

326. (1.30) A transformer may be used

A. to convert an alternating current and voltage to a larger current at a higher voltage.
B. to transform alternating current into direct current.
C. to decrease an alternating voltage and increase the current.
D. to step up the voltage of a battery.
E. to transform an alternating voltage at one frequency to an alternating voltage at another frequency.

327. (1.30) "In a circuit the sum of the currents flowing into a junction equals the sum of the currents flowing out of the junction" is a statement of

A. Lenz's Law. **B.** Ohm's Law.
C. Faraday's Law of electrolysis.
D. Law of the conservation of energy.
E. Law of the conservation of matter.

328. (1.30) Two single turns of wire are placed close together and facing each other. When a current starts through one of the coils,

A. a momentary current occurs in the second coil.
B. a current which increases from zero to a final steady value occurs in the second coil.
C. no current occurs in the second coil.
D. a current is induced in the second coil as long as a current exists in the first coil.
E. a constant electromotive force is induced in the second coil.

329. (1.30) In reference to standard electrode potentials between metals and their ions,

A. a positive value of E° means that the ion is a good oxidizing agent.
B. a negative value for E° means that the ion is easily reduced.
C. metals readily dissolve in acids if the value of E° for that metal is negative.
D. no metal has a smaller value for E° than that of hydrogen.
E. no oxidizing agent can act upon a metal if E° for that metal is a negative value.

330. (1.30) In the refining of blister copper

A. using the proper voltage, copper and metals of higher electrode potential are dissolved from the anode; of these, only copper is deposited on the cathode.
B. any gold or silver present is found dissolved in the electrolyte.
C. zinc is found in the anode sludge.
D. iron is deposited upon the cathode.
E. using the proper voltage, all metals except copper dissolve from the anode.

331. (1.30) In an electric lamp

A. electrons from the power source are burned up in the filament.
B. the electrons give up some of their energy in passing through the filament.
C. the potential difference between the ends of the filament is continually decreasing.
D. the current becomes smaller as it flows through the lamp.

332. (1.30) In an electric lamp

A. part of the current is consumed.
B. some electrons lose their charge and become neutrons.
C. electrons give up some of their energy.
D. electrons are transformed into photons.
E. none of these things happen.

333. (1.30) A man moves from a district where the electric power company has supplied 60 cycle AC at 110 volts to one where the supply is 110 volt DC. Of his various household electric appliances which are used on the circuit in the first place, he may be certain that he cannot now use the

A. electric flatiron. **B.** electric sewing machine.
C. reading lamps.
D. transformer for the small boy's electric railroad.
E. electric toaster.

334. (1.30) The magnetic field associated with a long straight wire carrying a constant current is

A. zero as soon as the current reaches its steady value.
B. a uniform field.
C. greater at the high potential end than at the low potential end.
D. unvarying in direction and magnitude at a given point.
E. continually changing in direction.

335. (1.30) The action of an induction coil depends upon

A. abrupt changes in magnetic fields.
B. exactly the same effects as are present in an electric generator.
C. an alternating current in the primary coils.
D. absence of inductance in the primary coils.

336. (1.30) To send 10 amperes of direct current through a wire of given resistance we must choose the correct

A. capacity. **B.** inductance. **C.** reactance.
D. impedance. **E.** potential difference.

337. (1.30) A magnetic field exerts a force upon an electric charge only when the charge is

A. at rest, the field stationary.
B. moving in the direction of the field.
C. moving against the direction of the field.
D. moving across the field.

338. (1.30) What advantage is gained by connecting house lights in parallel instead of in series?

A. The resistance in each filament is increased.
B. The voltage across a given lamp is not affected by the other lamps.
C. Fewer amperes of current need to flow through each light.
D. The current that flows through one light flows through all of the lights.

339. (1.30) In a generator a flat rectangular coil of wire is caused to rotate at constant speed between the two poles of a strong magnet. The electromotive force induced in the coil is

A. greatest when the plane of the coil is perpendicular to the lines of force.
B. greatest when the plane of the coil is parallel to the lines of force.
C. constant at all times during rotation of the coil.
D. greatest when the maximum flux passes through the coil.
E. least when the number of flux lines through the coil is changing most rapidly.

Items 340 - 349 concern a comparison of the properties of electric and magnetic fields. It is to be assumed, in answering them, that magnetic fields are due entirely to electric charges in motion, and that no bodies other than the electric charges are present. For convenience in expression, the following terminology will be used; the "bases" of a field will be taken to mean charges, if the field is electric, moving charges if it is magnetic; the "strength" of a base will be taken to mean the quantity of charge q in the former case, the "galvanic strength" q v in the latter.

Mark each of the following

A. if it is true of all electric and magnetic fields.
B. if it is true of static electric and magnetic fields, but not of all electromagnetic fields.
C. if it is true of magnetic fields but not of electric fields.
D. if it is true of electric fields but not of magnetic fields.
E. if it is true neither of electric nor of magnetic fields.

340. (1.30) The contribution of a base to the field intensity at a given point is proportional to the strength of the base.

341. (1.30) The contribution of a given base to the field intensity is the same for all points equidistant from the base.

342. (1.30) The lines of force of the field all start and end upon bases of the field.

343. (1.30) The lines of force of the field all are closed curves which "loop" around the bases.

344. (1.30) Considering a set of points all in the same (rectilinear) direction from a given base, the contribution of that base to the field intensity at the various points at a given time varies inversely with the square of the distance between the base and the point at that time.

345. (1.30) The number of lines of force in the field is determined entirely by the aggregate strength of the bases.

346. (1.30) The force exerted by the field upon a base does not have the same direction as the field intensity.

347. (1.30) The force exerted by one base upon another is directed perpendicularly to the line of motion of the latter.

348. (1.30) The total energy of the field is determined entirely by the aggregate strength of the bases.

349. (1.30) The direction of the force exerted by one base upon another at a given time is not influenced by the position at the same or an earlier time of the base exerting the force.

350. (1.30) Under the influence of an electric field, electrons in a metal would tend to move

A. from position of higher potential, and consequently higher potential energy, to lower.
B. from positions of lower potential and consequently higher potential energy, to higher potential and lower energy.
C. from positions of higher potential, and consequently lower potential energy, to lower potential and higher energy.
D. from positions of lower potential, and consequently lower potential energy, to higher.
E. from positions of higher potential to lower; questions of energy are irrelevant.

351. (2.00) The conclusion stated in answer to the preceding question is based upon the principle that

A. a current is produced by a fall in potential.
B. a moving charge possesses kinetic energy.
C. the kinetic energy of a charge moving uniformly is constant, and hence such a charge requires no influx of energy.
D. charges being accelerated by electric forces are sources of energy radiation.
E. a charge moving in the direction of the electric force upon it is used up energy of the field.

352. (1.30) A current will flow in a conductor if two of its points are at different potentials because

A. a potential difference constitutes an electromotive force and always generates a current.
B. it is a consequence of the definition of potential that two points between which no motion of electric charges occurs are at the same potential.
C. current is defined by Ohm's Law as the ratio of potential difference to resistance; hence if the potential difference differs from zero, so does the current.
D. a conductor is a body which tends to bring electric charges from higher to lower potential energy.
E. the existence of a potential difference implies the existence of forces acting upon the charges which, in a conductor, are free to move.

353. (2.00) Which of the following would provide an experimental test of the proposition that charges in conductors reside entirely upon their surface?

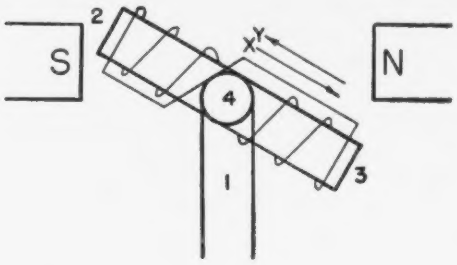
A. Drilling a hole in a conducting body, charging the body, inserting a wire deep into the hole and connecting the other end of the wire to an electroscope.

B. Connecting the surface of a charged conductor with the earth, and observing whether it is thereby discharged.
C. Touching a charged conductor to the outside surface of a hollow, uncharged conducting container and then observing whether the first conductor has been discharged.
D. Touching a charged conductor to the inside surface of a hollow, charged conducting container and then observing whether the first conductor has been discharged.
E. Breaking a solid, charged conductor in two and examining the freshly exposed surfaces (which constituted interior portions of the conductor) to see whether in fact they are uncharged.

354. (2.00) The assertion that like charges repel one another is best regarded as

A. an arbitrary definition.
B. an expression of the observed fact that charged bodies which repel one another act alike toward all other electrified bodies.
C. based upon the observation that charged bodies of the same material repel one another.
D. the only possibility remaining once it has been ascertained that unlike charges attract one another.
E. a consequence of Coulomb's Law.

355. (2.10) The following diagram represents a motor and the direction of rotation is shown by the large arrows. The poles marked N and S are similar to the poles of an ordinary horseshoe magnet. The direction of the current is shown by



A. arrow X. **B.** arrow Y.

356. (2.10) The device immediately surrounding the number 4 is

A. an armature. **B.** a field pole.
C. a pair of slip rings. **D.** a commutator.
E. a rotor.

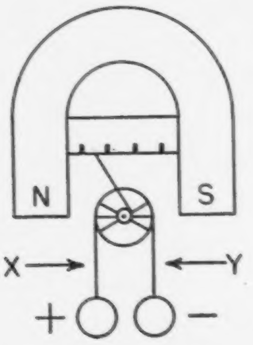
357. (2.10) We know from the device mentioned in the preceding exercise that this motor is

A. an induction motor. **B.** a direct current motor.
C. an alternating current motor.
D. a motor that will operate on either alternating or direct current.

358. (2.10) At 2 and 3 respectively are

A. armature poles temporarily north and south.
B. armature poles temporarily south and north.
C. permanent north and south poles of the armatures.
D. field poles temporarily north and south.

359. (2.10) The following device, as drawn, represents a simple ________.



For items 360 - 367, refer to the device shown in item 359, and use the key given below.

KEY

A. Voltmeter. **B.** Galvanometer. **C.** Ammeter.
D. All of these. **E.** None of these.

360. (2.10) If a high resistance should be inserted in the wire leading to the coil at X, the instrument would be used as________.

361. (2.10) If a low resistance wire is inserted connecting points X and Y on the wires to the coil, the device would be used as________.

362. (2.10) The device (with necessary modifications, if any) must be connected in parallel with part of the outside circuit if it is to be used as________.

363. (2.10) The device (with necessary modification, if any) is to be used to detect the presence and direction of very small currents but not to measure them.

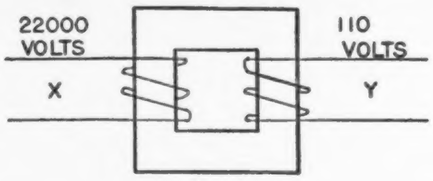
364. (2.10) If the leads to the coil are arranged so that it can continue to turn, and if current can be reversed every half turn, it is a________.

365. (2.10) To measure the electromotive force of a cell, ________ should be used.

366. (2.10) The coil becomes a magnet when current is passed through it.

367. (2.10) To measure the current flowing through a lamp, ________should be used.

Items 368 - 371. Refer to the diagram and key given below.



KEY

A. Greater than. **B.** Less than. **C.** The same as.

368. (2.10) The number of turns of Y will be________the number of turns on X.

369. (2.10) Assuming that the voltages given are correct, the number of amperes of current in Y will be________the number of amperes in Y.

370. (2.10) Assuming 100% efficiency, the number of kilowatts of power obtained through the Y will be________that delivered in line X.

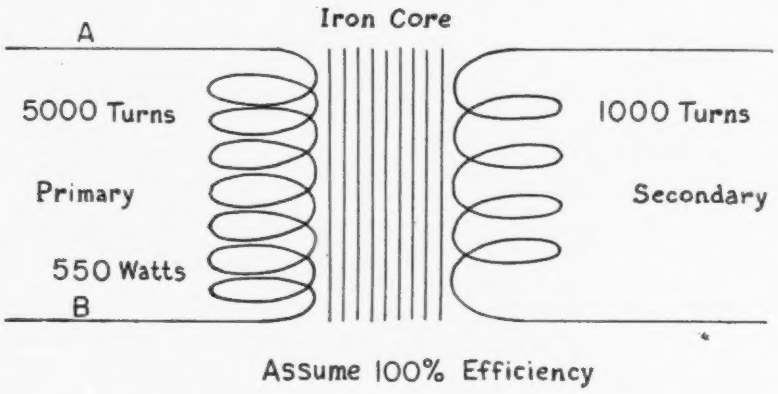
371. (2.10) The cycles of alternation of current per second in Y will be________the number of alternations in X.

Item 372 deleted.

373. (2.10) A step-down transformer is used on a 2200 volt distribution line to deliver 40 amperes at 110 volts. About what current (in amperes) is drawn from the distribution line?

A. 4/11. **B.** 2. **C.** 20. **D.** 80. **E.** 800.

Items 374 - 376 refer to the following diagram of a transformer.



3 (2) When the transformer is properly connected to a circuit and the current in the primary is 5 amperes, the current in the secondary is

A. 1 ampere. **B.** 5 amperes. **C.** 22 amperes.
D. 25 amperes. **E.** none of these.

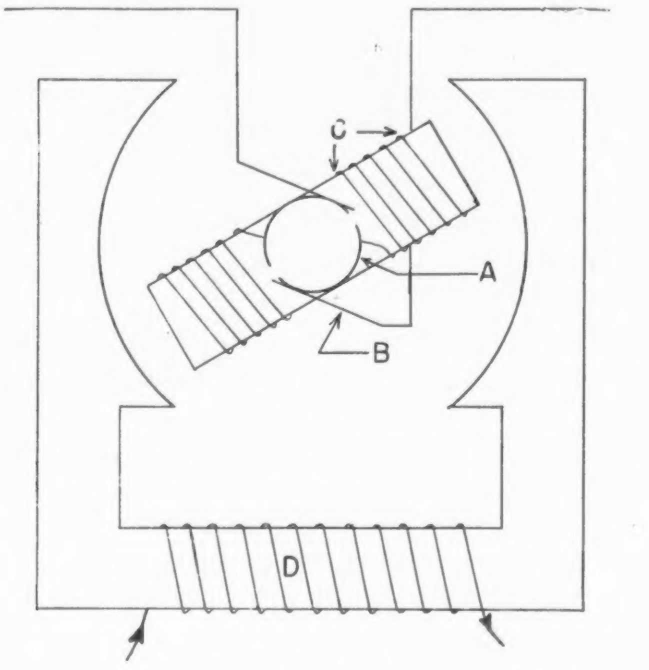
375. (2.10) In the preceding question, the voltage across the secondary is

A. 22 volts. **B.** 55 volts. **C.** 110 volts.
D. 550 volts. **E.** none of these.

376. (2.10) When the transformer is in use, the electron flow is

A. from the primary to the secondary through the iron core.
B. from the primary to the secondary and the secondary to the primary through the iron core.
C. only from A to B in the primary.
D. only from B to A in the primary.
E. from A to B and B to A in the primary.

Items 377 - 380 refer to the following diagram.



377. (2.10) The apparatus is a representation of a simple

A. direct current generator. **B.** direct current motor.
C. alternating current generator.
D. alternating current motor.
E. the apparatus can be either a simple motor or generator.

For items 378 - 380 select from the key the name of the part labelled.

KEY

A. Brush. **B.** Commutator. **C.** Slip ring.
D. Armature. **E.** Field coil.

378. A. (2.10) **379.** B. (2.10) **380.** C. (2.10)

381. (2.10) A transformer delivering 1100 watts has a primary voltage of 220 volts and a secondary voltage of 110. The current in the secondary is approximately

A. 0.1 amperes. **B.** 2.0 amperes. **C.** 5.0 amperes.
D. 10.0 amperes. **E.** 550. amperes.

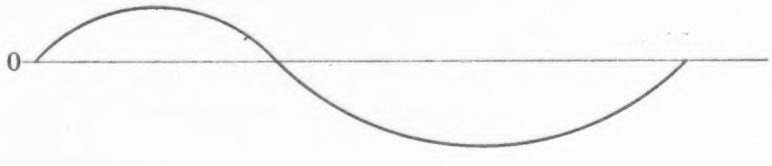
382. (2.10) A transformer has 10 turns and 110 volts in the primary. In the secondary there are 100 turns. The voltage in the secondary is

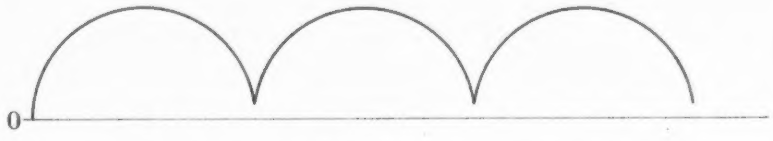
A. 11. **B.** 110. **C.** 1100. **D.** 11,000.
E. none of the above.

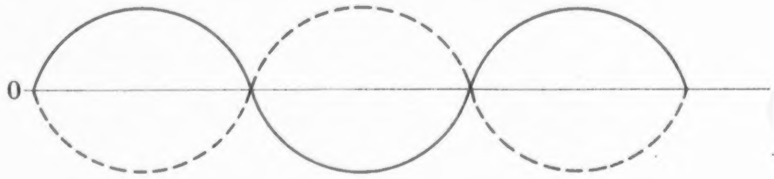
383. (1.30) In the above transformer the

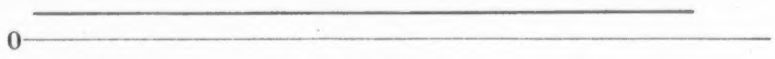
A. power input is less than the power output.
B. amperage in the primary is less than the amperage in the secondary.
C. power input is approximately the same as the power output.
D. current in the primary is alternating and in the secondary is direct.
E. current in both the primary and secondary is direct.

Items 384 - 389 refer to the numbered diagrams. For each item select the number of the diagram which applies.

1.


2.


3.


4.


5. None of these

384. (2.10) The output of a direct current generator.

385. (2.10) A standing wave.

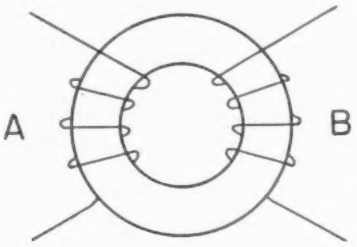
386. The current from a storage battery.
(2.10)

387. The output of a transformer.
(2.10)

388. A longitudinal wave.
(2.10)

389. The output of an alternating current generator.
(2.10)

Items 390 - 395.



Coil A of the transformer is connected to the slip rings of a generator which delivers 60 cycle alternating current. Transformers are useful because the voltage of the induced current taken from the secondary can be made any desired multiple or fraction of the primary voltage by suitable winding of the coils. If the number of turns of wire in the secondary coil is the same as the primary voltage coil, the voltage is the same. If the secondary has twice as many turns, its voltage is twice that of the primary. If it has one-third as many turns, its voltage is one-third that of the primary, etc.

Likewise the current strength in the secondary depends simply on the number of windings in the two coils. It is greater in the secondary than in the primary if the number of turns is less, and vice versa; that is a transformer which reduces voltage produces a current of greater amperage, one that increases voltage produces a current of smaller amperage.

After each exercise number on the answer sheet, blacken the one lettered space which designates the correct answer.

390. Coil A is called the
(2.10)

A. commutator. **B.** secondary. **C.** primary.
D. core. **E.** solenoid.

391. The transformer will work best if coil A is connected to
(1.10)

A. a lead battery. **B.** a dry cell. **C.** a bar magnet.
D. an electromagnet. **E.** an alternating current.

392. The current in the primary
(1.10)

A. changes in direction 60 times per minute.
B. changes in direction 60 times per second.
C. changes in direction 120 times per second.
D. changes in direction 120 times per minute.
E. flows in one direction.

393. In the area around coil A, there
(1.10)

A. is a constant magnetic field.
B. is a magnetic vacuum.
C. are magnetic lines that come, go, and reappear in opposite direction.
D. are cathode rays. **E.** are beta rays.

Items 394 - 397. Assume that no electrical energy is lost as heat in the transformer.

394. If coil B has 440 turns of wire and coil A has 110 turns of wire, the amperage available at B will be
(2.10)

A. ¼ times that supplied coil A.
B. 4 times that supplied coil A.
C. 110 times that supplied coil A.
D. 440 times that supplied coil A.
E. some amperage other than those listed.

395. If coil B has 440 turns of wire and coil A has 110 turns of wire, the voltage at B will be
(2.10)

A. ¼ times that supplied coil A.
B. 4 times that supplied coil A.
C. 110 times that supplied coil A.
D. 440 times that supplied coil A.
E. some voltage other than those listed.

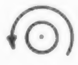
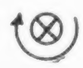
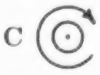
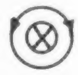
396. A transformer has 500 turns in the primary to 100 turns in the secondary. If current is supplied at 110 volts and 2 amperes, current would be delivered at
(2.10)

A. 550 volts. **B.** 22 volts. **C.** 110 volts.
D. 500 volts. **E.** 1.1 volts.

397. Since the transformer described in the preceding exercise is assumed to be 100 per cent efficient, the number of amperes of current available from the secondary is equal to
(2.10)

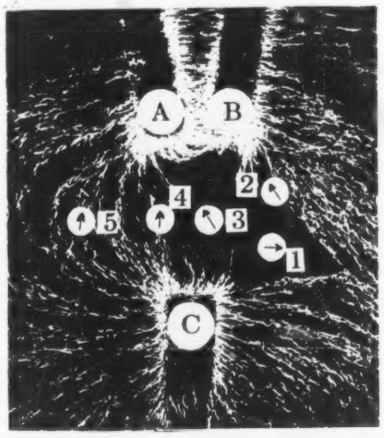
A. 2 amperes. **B.** 0.4 amperes. **C.** 100 amperes.
D. 10 amperes. **E.** 5.5 amperes.

398. When electrons flow through a wire, magnetic lines of force exist around the wire. Suppose that (•) means electrons coming toward you through a wire and that (x) means electrons flowing away from you through a wire. Under these conditions, which *one* of the following diagrams is entirely correct?
(2.10)

A  B  C  D 

E None of these diagrams is correct.

Items 399 - 401 refer to this diagram of the photograph which follows.



399. In the photograph, the magnetic poles that are similar are
(2.10)

A. A and B. **B.** B and C. **C.** A and C.
D. A, B, and C.

400. If arrow #5 is pointing in the direction a compass needle would point in that location, then the arrow that does not show the proper direction of a compass needle is in location
(2.10)

A. 1. **B.** 2. **C.** 3. **D.** 4.

401. A compass needle would be least reliable as an indication of the direction of the lines of force in position
(2.10)

A. 1. **B.** 2. **C.** 3. **D.** 4. **E.** 5.

402. Two N magnetic poles repel each other with a certain force. If one of them is replaced with a S pole of the same magnetic strength, the force would
(2.10)

A. be increased.
B. be decreased but not to zero. **C.** vanish.
D. remain of equal magnitude and in the same direction.
E. be in the reverse direction but of equal magnitude.

403. If two unit magnetic poles are moved twice their original distance apart the force exerted on one another will now be, compared to the original,
(2.10)

A. ¼. **B.** ½. **C.** ¾. **D.** 2. **E.** 4.

404. An electrical appliance whose resistance is 200 ohms draws a current of one half ampere. The voltage applied is, in volts,
(2.10)

A. 0.40. **B.** 40. **C.** 50. **D.** 100. **E.** 200.

405. A current of two amperes flows for one hour. The quantity of electricity which flows past a given point is
(2.10)

A. 0 coulombs. **B.** 120 coulombs.
C. 3600 coulombs. **D.** 7200 coulombs.
E. 10,800 coulombs.

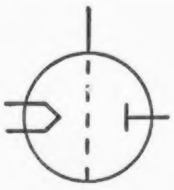
406. Six hundred electrons are required to reduce 600 silver ions (Ag^+) to silver (Ag) in an electrolysis. This number of electrons would reduce how many aluminum ions (Al^{+++}) to aluminum?
(2.10)

A. 200. **B.** 300. **C.** 400. **D.** 600. **E.** 1800.

407. A certain 60-watt light bulb is designed to operate at 120 volts potential difference. When operating at rated voltage, about what current (in amperes) flows through the lamp?
(2.10)

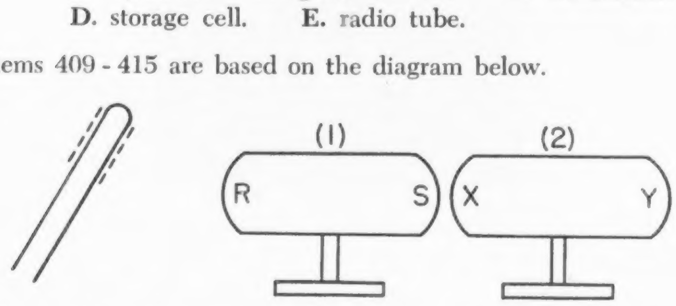
A. 60. **B.** 2. **C.** 240. **D.** 7200. **E.** ½.

408. This symbol represents a
(2.10)



A. dynamo. **B.** galvanometer. **C.** transformer.
D. storage cell. **E.** radio tube.

Items 409 - 415 are based on the diagram below.



After each number on the answer sheet, blacken the *one* space which designates the correct answer.

A negatively charged rod is brought close to but does not touch two insulated conductors which touch at one end.

409. R will be
(2.10)

A. positive. **B.** negative. **C.** neutral.

410. Y will be
(2.10)

A. positive. **B.** negative. **C.** neutral.

While the rod is still there the conductors are separated. The rod is then removed.

411. Body number (1) will now have
(2.10)

A. a positive charge. **B.** a negative charge.
C. no charge.

412. Body number (2) will now have
(2.10)

A. a positive charge. **B.** a negative charge.
C. no charge.

Consider that the negatively charged rod originally touched point R while bodies (1) and (2) were in contact.

413. Body number (1) would then have
(2.10)

A. a negative charge. **B.** a positive charge.
C. no charge.

414. Body number (2) would then have
(2.10)

A. a negative charge. **B.** a positive charge.
C. no charge.

415. The charge on the rod could be detected by
(2.10)

A. an ammeter. **B.** a galvanometer.
C. a spinthariscope. **D.** an electroscope.
E. a Wilson cloud chamber.

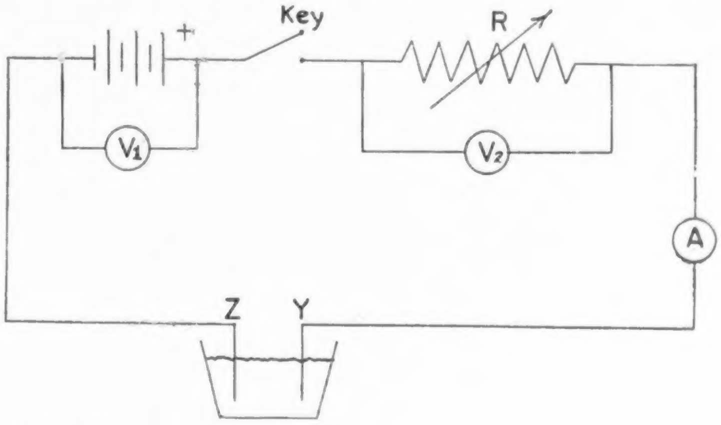
416. The Law of Electrostatics states that the force of attraction or repulsion between two charged bodies is equal to the product of the charges divided by the square of the distance between them. If two charged bodies have each 2 units of charge and are 2 cm. apart, the force acting between them in dynes is
(2.10)

A. 1. **B.** 2. **C.** 4. **D.** 8. **E.** none of these.

417. The resistance of an electric device marked 110 watts, 110 volts is
(2.10)

A. 1 ohm. **B.** 55 ohms. **C.** 220 ohms.
D. 110 ohms. **E.** none of these.

Items 418 - 420 refer to the following electrical diagram.



418. The voltmeter labeled V_1
(2.10)

A. will not give a reading unless the key is pressed.
B. measures the current when the key is pressed.
C. reads the same as V_2 when the circuit is closed.
D. measures a potential difference whether the key is pressed or not.
E. is in series in the circuit.

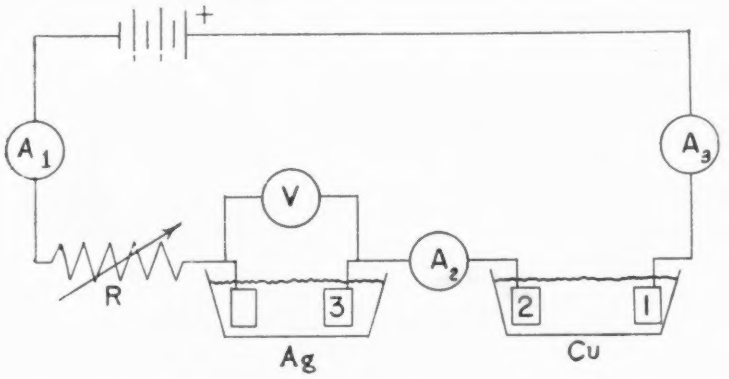
419. Increasing the amount of resistance at R will (when the
(2.10) key is pressed)

- **A.** increase the reading of A.
- **B.** not affect the rate of electrolysis at Z-Y.
- **C.** change the electromotive force of the battery.
- **D.** decrease the current in the circuit.

420. If electrolysis is carried out at Z-Y with an electrolyte
(2.10) of $CuSO_4$

- **A.** plate Z may be made of silver.
- **B.** plate Y is a cathode.
- **C.** copper will be deposited on Y.
- **D.** electrons will enter the cell at Y.
- **E.** less current will flow through Z than R.

Items 421 - 423 refer to the following diagram for copper and silver plating.



421. Which one of these is true?
(2.10)

- **A.** R is a variable inductance.
- **B.** V measures the current through the silver plating cell.
- **C.** Equal weights of copper and silver will be deposited since the two cells are in series with each other.
- **D.** Ammeter A_1 will read higher than A_2 or A_3.
- **E.** Ammeter A_2 and A_3 will have the same reading.

422. Which one of these is true?
(2.10)

- **A.** The electron flow from the battery is to the right.
- **B.** The voltmeter V reads the e.m.f. of the circuit.
- **C.** Copper will be deposited on plate 2.
- **D.** Current from a transformer would work just as well.
- **E.** Plates 2 and 3 are anodes.

423. Which one of these is true?
(2.10)

- **A.** If R is increased in value, the current will increase.
- **B.** The ammeters in the circuit are connected in parallel.
- **C.** The diagram is incorrect for carrying on electroplating.
- **D.** Electroplating is an example of electrolysis.
- **E.** The unmarked plate in the Ag cell must be made of silver.

424. The force acting between electrostatic charges is given
(2.10) by the formula

$$F = k\,\frac{q_1q_2}{d^2}$$

Suppose a charged body acts on another body having a charge $+q_1$ with a force F. If the charge were $-q_1$ under the same conditions, the force would

A. be decreased but not to zero. **B.** be increased.
C. vanish. **D.** be in the same direction.
E. be in the reverse direction.

425 - 428 are to be answered with the aid of equations from this list:

$I = \frac{Q}{t}$
$P = VI$
$H = .241^2R^t$
$W = VI^t$
$I = \frac{V}{R}$

P power
W energy
R resistance
I current
Q quantity
H heat
t time
V potential difference

425. The quantity of electricity used in 10 minutes by a
(2.10) toaster marked 5 amperes, 110 volts is

A. 5500 amperes. **B.** 3000 watts. **C.** 330,000 ohms.
D. 3000 joulves. **E.** none of these.

426. The resistance of an electric soldering iron marked 220
(2.10) watts, 110 volts is

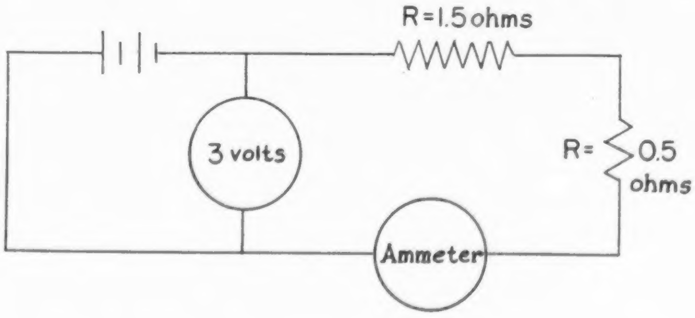
A. .50 ohms. **B.** 2.0 ohms. **C.** 55 ohms.
D. 11 ohms. **E.** none of these.

Item 427 deleted.

428. If the rate is 4 cents per KWH, for 10 cents a 100
(2.10) watt light bulb can be run for

A. 2.5 hours. **B.** 10 hours. **C.** 25 hours.
D. 40 hours. **E.** none of these.

Item 429 refers to the following diagram.



429. The ammeter will read
(2.10)

A. .25 amperes. **B.** .75 amperes. **C.** 1.5 amperes.
D. 2.0 amperes. **E.** none of these.

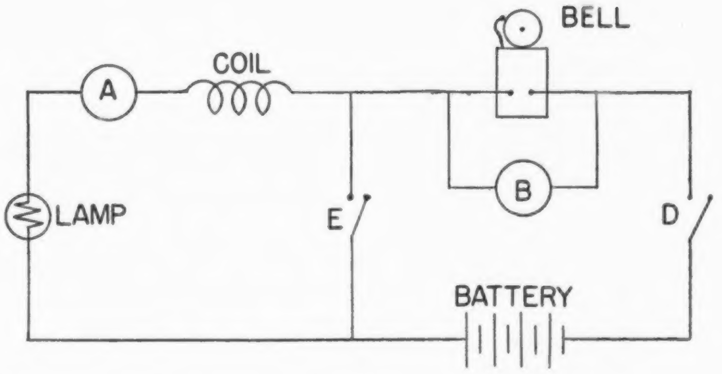
430. When a storage cell normally discharges, the anode
(2.10) changes from PbO_2 to $PbSO_4$; during this change

- **A.** the specific gravity of the electrolyte increases.
- **B.** the PbO_2 is reduced.
- **C.** the voltage drops from two volts to zero.
- **D.** the Pb increases in valence.
- **E.** the anode becomes negatively charged.

431. If one were to compare electricity with water, the cou-
(2.10) lomb would come the nearest to representing a measure of

- **A.** the discharge of a pipe, for example, 10 cu. feet per second.
- **B.** the pressure of water in a pipe, for example, 10 lbs./sq. inch.
- **C.** the time rate of flow of water, for example, 10 feet per second.
- **D.** quantity of water, for example, a bucketful.
- **E.** density of water, for example, pounds per cubic foot.

Items 432 - 436 refer to the following diagram.



In answering the items remember

a. all of the wiring (except the coil and that inside the instruments) is of the same size and material.
b. the wire of the coil is of greater resistance than the other external wiring.

432. The instrument A is correctly connected and used. It
(2.10)

A. is a voltmeter. **B.** measures kilowatt hours.
C. measures drop in potential through the coil.
D. can be used indirectly to measure the resistance of the circuit when switch E is open and D closed if the e.m.f. of the battery is known.

433. The correct statement is: The lamp will
(2.10)

A. light when switch E is closed and D open.
B. not light unless both switches are closed.
C. light when switch D is closed and E open.
D. light if both switches are open.

434. The lamp will be brightest when
(4.20)

A. switch E is open and D closed.
B. switch E is closed and D open.
C. both switch E and D are closed.
D. in two of the above cases there will be no difference in brightness.

435. The instrument B
(2.10)

A. is connected in series with the bell.
B. measures the amperage through the bell.
C. measures the power used by the bell.
D. measures the drop in potential through the bell.

436. The correct statement is:
(2.10)

A. The switch E is in series with the lamp.
B. The electron current flows first through the lamp and then through instrument A.
C. If the battery were replaced by an alternating current generator the lamp would no longer light unless the coil were removed.
D. It is not possible to manipulate the switches in such a manner that the lamp will light and the bell remain silent.

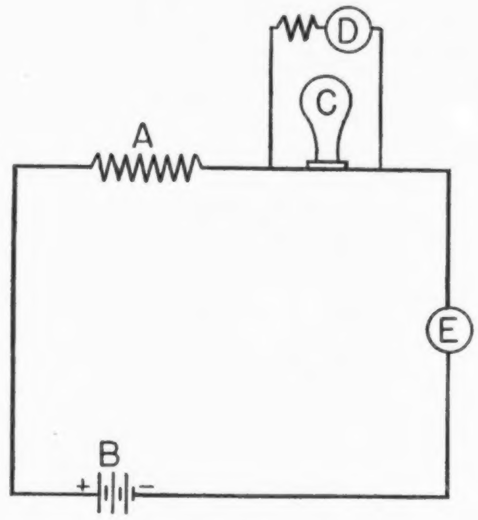
437. The correct statement is: Without rewiring
(2.10)

A. the bell cannot be made to ring if the lamp burns out.
B. the lamp cannot be made to light if the bell burns out.
C. the lamp can be made to light if the coil burns out.
D. the bell will ring if one of the plates is removed from the battery.

438. An electric lamp is labeled 100 watts, 120 volts. It uses
(2.10) in amperes

A. 1.20. **B.** .642. **C.** 8.92. **D.** 64.1. **E.** .833.

Items 439 - 447. In the sketch are shown the connections of the instruments used in measuring the current (amperes and voltage in a circuit or part of a circuit). The instruments referred to by circles are an ammeter and a voltmeter. The letter C refers to a lamp. After each item number on the answer sheet, blacken the one lettered space which designates the part of the diagram to which the item correctly refers.



439. Measures a difference of potential, of voltage drop.
(2.10)

440. Measures the current in amperes flowing in the circuit.
(2.10)

441. A high resistance is in series with this instrument.
(2.10)

442. Has a shunt (by-pass) in parallel with the instrument.
(2.10)

443. Might be placed in any place in the circuit.
(2.10)

444. Must be connected across, or in parallel, with the part
(2.10) of the circuit where the measurement is to be made.

445. The device which furnishes the current on which meas-
(2.10) urements are to be made in the circuit sketched.

446. Device for converting electrical energy largely into
(2.10) visible radiant energy.

447. Device for converting electrical energy largely into heat
(2.10) energy.

448. Given Coulomb's Laws: $F = \frac{Q_1Q_2}{kd^2}$ where $k = 1$.
(2.10)

The electric field intensity two cm. from a positive charge of 100 electrostatic units is

A. 2500 dynes per esu. **B.** 50 dynes per esu.
C. 25 dynes per esu. **D.** ½ dynes per esu.
E. none of the above.

449. If the same charges are ½ cm. apart, the force in dynes
(2.10) is

A. 1. **B.** 2. **C.** 4. **D.** 8. **E.** none of these.

450. (2.10) If two charged bodies have each 2 units of charge and are 2 cm. apart, the force acting between them in dynes is

A. 1. **B.** 2. **C.** 4. **D.** 8. **E.** none of these.

451. (2.10) The cost of electrical energy used in operating ten 60-watt electric light bulbs each operating for five hours, if the cost of the electrical energy is 6c per kilowatt-hour is

A. $1.80. **B.** 18 cents. **C.** 1.8 cents.
D. 12 cents. **E.** 10 cents.

452. (2.10) The resistance of a toaster which takes 5 amperes from a 120-volt line is________ohms.

A. 600. **B.** 60. **C.** 20. **D.** 24. **E.** 6000.

Items 453 - 470. After each item number on the answer sheet, blacken the one lettered space which designates the diagram to which the item correctly refers.

453. (2.10) A device for producing electrical energy from chemical change (from chemical energy).

454. (2.10) A device for converting radiant energy (light) into electrical energy.

455. (2.10) It converts mechanical energy into electrical energy flowing in a single direction.

456. (2.10) It converts mechanical energy into electrical energy which reverses its direction of flow at regular intervals.

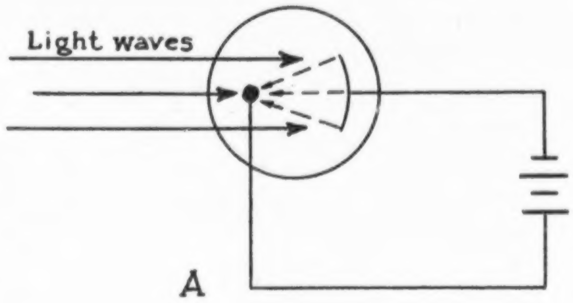
457. (2.10) A device which might be used to convert direct flowing electrical energy into mechanical energy.

458. (2.10) A device which might be used to convert alternating current into mechanical energy.

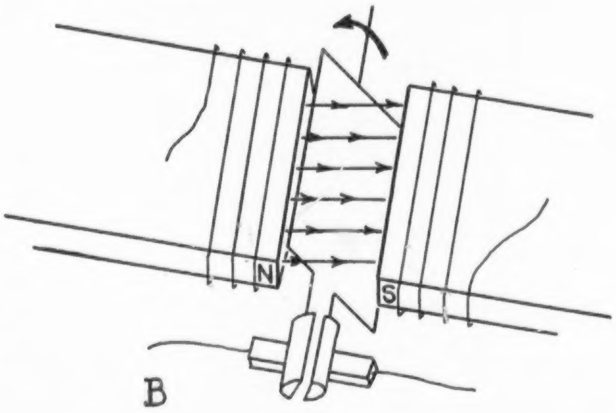
459. (2.10) It operates on the principle known as the "Edison Effect."

460. (2.10) It operates on the principle known as the "photoelectric effect."

461. (2.10) Various forms and modifications of this device are used in rectifiers, radio and television circuits, etc.



A



B

462. (2.10) The dry cell operates on the principle utilized in this device.

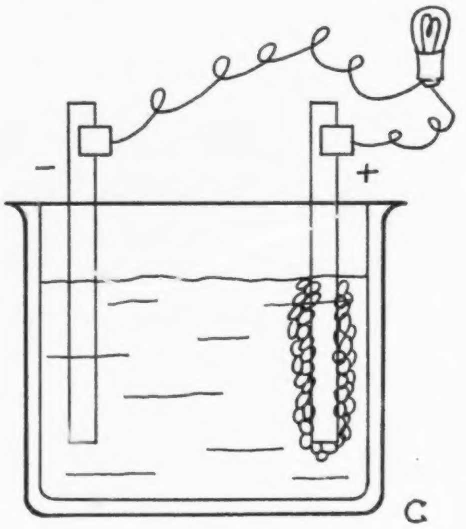
463. (2.10) The electrical energy consumed in our homes and offices was produced by a similar device.

464. (2.10) The energy used in large scale electroplating could come directly from this device.

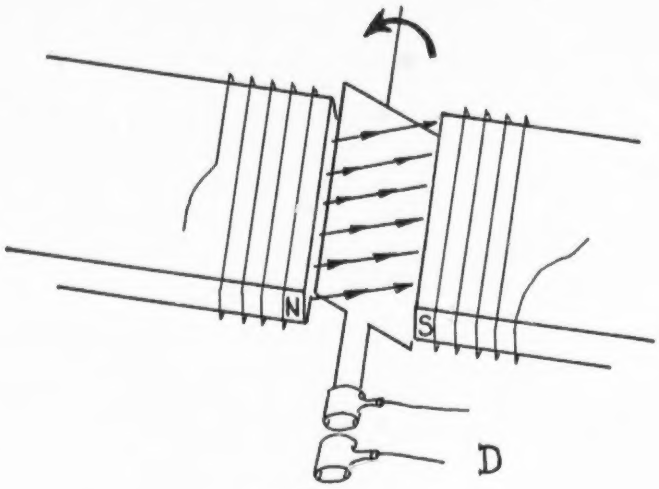
465. (2.10) Modified forms of this device are known as "electric eyes."

466. (2.10) This device is a "commutator."

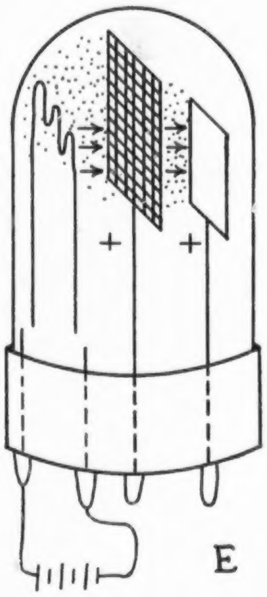
467. (2.10) This device has a pair of "slip rings."



C



D



E

468. (2.10) This device operates only in the presence of some form of radiant energy.

469. (2.10) Of the various devices sketched, a form of this one was the first to be used to produce a flow of electrons in a circuit.

470. (2.10) In this device atoms of an active metal are converted into positive ions through electron loss.

471. (2.10) The energy used by a refrigerator requiring 10 amperes from a 110-volt line in one hour is________kilowatt hours.

A. 11. **B.** 1100. **C.** 6600. **D.** 1.1. **E.** 110.

472. (2.10) The current flowing in a lamp whose resistance is 300 ohms and which is connected to a 120-volt line is ________amperes.

A. 250. **B.** 36,000. **C.** 40. **D.** 2.5. **E.** 0.4.

473. (2.10) The power in watts taken by an electric heater using 10 amperes on a 115-volt circuit is

A. 11.5 **B.** 115. **C.** 1150. **D.** 11,500. **E.** .087.

An electric toaster using 4 amperes is connected to a 120-volt line for 200 seconds. (W = V.I.^{t}); (V = I.^{r}); (Watts = V.I.).

474. (2.10) The resistance of the toaster is

A. 30 ohms. **B.** 480 ohms. **C.** 3000 watts.
D. 3000 joules. **E.** 96,000 ohms.

475. (2.10) If the rate is 5c per kilowatt-hour the cost in cents of running this toaster for one hour is

A. 0.7. **B.** 2.4. **C.** 4.8. **D.** 5.0. **E.** 7.2.

476. (2.10) The total energy consumed is

A. 480 joules. **B.** 480 watts. **C.** 3000 ohms.
D. 96,000 watts. **E.** 96,000 joules.

477. (2.10) The power rating of the toaster is

A. 480 ohms. **B.** 480 watts. **C.** 96,000 ohms.
D. 96,000 joules. **E.** 96,000 ergs.

478. (2.10) The resistance of an electric device marked 110 watts, 110 volts is

A. 1 ohm. **B.** 55 ohms. **C.** 220 ohms.
D. 110 ohms. **E.** none of these.

Item 479 deleted.

480. (2.10) The resistance, (R) for copper wire at any given temperature (t) is given by the equation

$$R = 0.02057\ (1 + 0.00387\ t + 0.00000579\ t^2)$$

Which of the following statements is not correct?

A. Resistance of copper wire increases with temperature.
B. Variations of one degree or less in temperature, cause little change in resistance (R).
C. An increase of one degree in temperature causes the same increase in resistance (R) regardless of the initial temperature.
D. For t = 0, R = 0.02057.
E. The formula is of little value unless one knows the kind of units in which (t) and (R) are to be measured.

Items 481 - 483 deleted.

484. (2.10) A current of 2 amps. passes through a 60-volt lamp for one minute. The power used is

A. 25 watts. **B.** 50 watts. **C.** 60 watts.
D. 75 watts. **E.** 120 watts.

485. (2.10) A wire 1 meter long is moved at the rate of 1 meter per second at right angles to a uniform magnetic field of 10,000 lines of force per square centimeter. The e.m.f. induced in the wire (in e.m.u.) is

A. 10^{-8}. **B.** 10^{-4}. **C.** 1. **D.** 10^4. **E.** 10^8.

Item 486 deleted.

487. (2.10) The electrochemical equivalent of copper is 0.00033. This means that

A. one coulomb deposits 0.00033 grams of copper.
B. 0.00033 coulomb deposits one gram of copper.
C. one ampere deposits 0.00033 grams of copper.
D. 0.00033 ampere deposits one gram of copper.
E. one atom of copper has a charge of 0.00033 coulomb.

488. (2.10) If the total number of magnetic lines of force through a coil having 5 turns changes from 50,000 lines to 100,000 lines in 0.01 sec., the induced e.m.f. in the coil is

A. 0.05 volt. **B.** 0.25 volt. **C.** 0.50 volt.
D. 1.0 volt. **E.** 2.5 volts.

489. (2.10) If an e.m.f. of 20 volts is developed across a coil by the current in the coil changing at the rate of 2 amperes per second, the magnitude of the inductance is

A. 5. **B.** 10. **C.** 15. **D.** 20. **E.** 40.

A transformer which is 100% efficient has 200 turns in the primary coil and 50 turns in the secondary coil.

490. (2.10) If there are 10 volts across the primary, the secondary voltage is

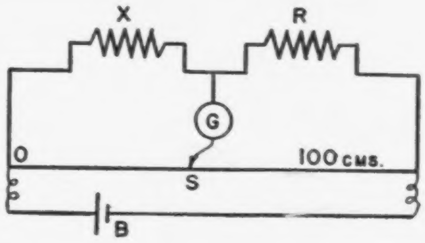
A. 2.5. **B.** 5. **C.** 10. **D.** 20. **E.** 40.

491. (2.10) If the primary current is 10 amperes, the current in the secondary circuit is (in amperes)

A. 2.5. **B.** 5. **C.** 10. **D.** 20. **E.** 40.

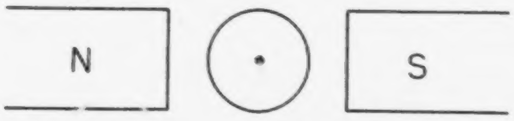
492. (2.10) In a Wheatstone bridge (see diagram) the resistance R is 60 ohms. If the switch S is at 40 cms. when the bridge is balanced the resistance X is

A. 24 ohms. **B.** 40 ohms. **C.** 90 ohms.
D. 36 ohms. **E.** 100 ohms.



493. (2.10) The diagram shows the front of a cathode ray tube. If a magnetic field is applied as shown the electron beam will

A. move up. **B.** move down. **C.** not move.
D. move to right. **E.** move to left.



494. A motor takes 50 amperes at 300 volts. If it delivers 15 horsepower (746 watts = 1 horsepower) at the pulley, the efficiency of the motor is nearly
(2.10)

A. 75%. **B.** 80%. **C.** 85%. **D.** 90%. **E.** 95%.

495. A magnet is 5 cm. long and has a pole strength of 5 unit poles. At a point 5 cm. from the south pole on a line through the north and south poles, the magnetic field intensity in dynes per unit N pole is
(2.10)

A. 0.5 toward magnet. **B.** 0.5 away from magnet.
C. 0.15 toward magnet. **D.** 0.15 away from magnet.
E. 0.25 toward magnet.

496. Points A and B are 100 cms. apart and point B is 200 e.s.u. of potential higher than point A. The work done on 4 e.s.u. of charge in carrying them from A to B is
(2.10)

A. 0.04 erg. **B.** 0.08 erg. **C.** 2 ergs.
D. 8 ergs. **E.** 800 ergs.

Items 497 - 498.

When 10 coulombs of charge are placed on a certain condenser the potential difference between the plates is 40 volts.

497. The capacity of the condenser is
(2.10)

A. 400 farads. **B.** 4 farads. **C.** 0.20 farad.
D. 0.25 farad. **E.** 200 farads.

498. The energy due to the charge is
(2.10)

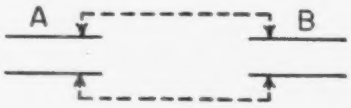
A. 400 joules. **B.** 4 joules. **C.** 0.20 joule.
D. 2.5 joules. **E.** 200 joules.

499. A condenser whose capacity is 20 microfarads is charged to a potential of 200 volts. The energy due to the charge is
(2.10)

A. 4000 joules. **B.** 4.0 joules. **C.** 0.40 joule.
D. 2000 joules. **E.** 0.10 joule.

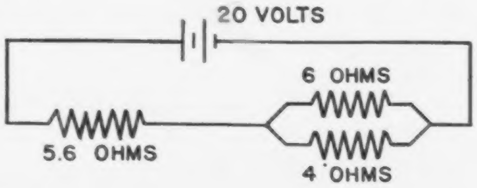
500. Condensers A and B have the same capacity. A is charged until its energy is 4 joules. The plates are then connected as indicated by the dotted lines. The energy in the two condensers is now
(2.10)

A. 20 joules. **B.** 10 joules. **C.** 2.0 joules.
D. 2.5 joules. **E.** 1.25 joules.



501. The resistance of the battery and connecting wires in the diagram in 2 ohms. The current in the circuit is
(2.10)

A. 1.28 amps. **B.** 1.08 amps. **C.** 4.82 amps.
D. 2.0 amps. **E.** 3.0 amps.



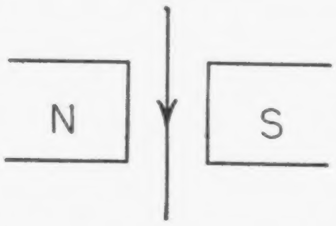
502. A current of 2 amps. passes through a 60-volt lamp for one minute. The power used is
(2.10)

A. 25 watts. **B.** 50 watts. **C.** 60 watts.
D. 75 watts. **E.** 120 watts.

Item 503 deleted.

504. If current flows downward in the wire between the poles of a magnet, as shown in the diagram, the wire moves
(2.10)

A. to the right. **B.** to the left.
C. toward the reader. **D.** away from the reader.
E. upward.



505. The product of the current in a conductor and the number of lines of force of a magnetic field which cut the conductor during its motion yields
(2.10)

A. the induced e.m.f. **B.** the force on the conductor.
C. the work done on the conductor.
D. the intensity of the magnetic field.
E. the total flux cut by the conductor.

506. A power line has a resistance of 2 ohms. If 220 amps are to be delivered at 110 at what voltage must it be put on the line?
(2.10)

A. 231 volts. **B.** 154 volts. **C.** 660 volts.
D. 550 volts. **E.** 131 volts.

507. The overvoltage of hydrogen
(2.10)

A. is due to the sluggishness with which hydronium ions are discharged at some metals.
B. explains why impurities slow down the solution of zinc in acids.
C. explains why iron rusts.
D. refers to the high voltage necessary to produce an electric discharge in gaseous hydrogen.
E. is responsible for the position of hydrogen at the top of the activity series.

508. If the magnetic intensity 10 cms. from the north pole of a very long bar magnet on a line with the axis of the magnet is 10 units, the intensity at a point 20 cm. from the north pole on this same line will be very nearly
(2.10)

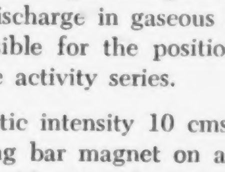
A. 2.5 units. **B.** 5 units. **C.** 20 units.
D. ¼ unit. **E.** 0.66 unit.

509. According to the ordinary conventions, an electrical current flowing north in a copper wire indicates
(2.10)

A. electrons in the wire are moving north.
B. electrons in the wire are moving south.
C. copper atoms are actually moving south.
D. copper atoms are actually moving north.
E. copper ions are moving south.

510. In a closed circuit containing two identical storage batteries as shown, we expect that
(2.10)

A. direct current is flowing.
B. alternating current is flowing.
C. the current is zero.
D. there is no complete conducting path.
E. the batteries are charging one another.

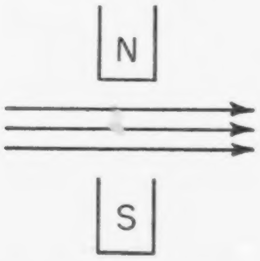


511. To use 6 twenty-five-watt lamps 4 hours a day for 30 (2.10 days costs, if the rate is 10 cents per kilowatt-hour,

A. \$1.20. **B.** \$1.80. **C.** \$1.50. **D.** \$7.20.
E. \$18.00.

512. A stream of cathode rays is moving from left to right (2.10) between the poles of a magnet as indicated. The rays are deflected

A. toward the N pole. **B.** toward the S pole.
C. out from the paper. **D.** into the paper.



513. A current of 2 amperes flows for ten minutes through a (2.10) resistance of 5 ohms. The power being used is

A. 100 watts. **B.** 200 watts. **C.** 600 watts.
D. 25 watts. **E.** 20 watts.

514. If it requires one unit of work to convey one unit of (2.10) electricity between two points,

A. there is a potential difference of one unit between the points.
B. the two points are at the same potential.
C. there must be a force of one dyne acting on the charge.
D. the points must be one centimeter apart.

515. Two resistances of 3 and 6 ohms are connected in (2.10) parallel. The combined resistance is

A. 3 ohms. **B.** 9 ohms. **C.** 18 ohms.
D. 1 ohm. **E.** 2 ohms.

516 - 517. A certain 60-watt light bulb is designed to operate at 120 volts potential difference.

516. When operating at rated voltage, about what current (2.10) is in the lamp, in amperes?

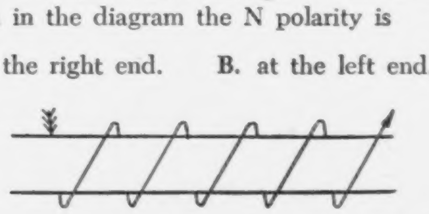
A. ½. **B.** 2. **C.** 180. **D.** 240. **E.** 7200.

517. About what is the resistance of the lamp filament, in (2.10) ohms?

A. ½. **B.** 2. **C.** 180. **D.** 240. **E.** 7200.

518. When a current flows through a coil in the direction (2.10) shown in the diagram the N polarity is

A. at the right end. **B.** at the left end.



519. If the N end of a magnet is thrust into the right end (2.10) of the coil the current induced in the coil is

A. in the direction indicated by the arrows.
B. in the opposite direction.

520. A 110-watt light bulb, a 500-watt toaster, and a 3000- (2.20) watt electric range all operate on a 110-volt circuit. The difference and wattages can best be explained by pointing out that the devices have different

A. sizes. **B.** capacitances. **C.** resistances.
D. voltages. **E.** uses.

521. Which of these would probably cause the fuse in a (2.20) houselighting circuit to be burned out?

A. A great decrease in the resistance of the circuit.
B. Connecting all the lights in the circuit in series.
C. A great increase in the resistance of the circuit.
D. A great decrease in the voltage applied to the circuit.
E. None of these.

522. According to the electromagnetic theory of light, the (2.20) most nearly correct formulation of the role of energy in optical processes is:

A. Energy is required to produce a ray of light; the energy thereby expended reappears in the form of heat, since bodies emit light only when they are hot.
B. Changes of energy occur in optical processes only when light is emitted or absorbed; emission involves an increase, absorption a decrease of the energy of bodies, and energy is conserved because emission is compensated precisely by absorption.
C. Changes of energy occur in optical processes only when light is emitted or absorbed; emission involves a decrease, absorption an increase of the energy of bodies, and energy is conserved because emission is compensated precisely by absorption.
D. Light itself possesses energy, since in a light wave the vectors representing the electric and magnetic intensities at a point vibrate, and such a vibration represents kinetic energy.
E. Energy is distributed throughout the electromagnetic field, with a density at each point determined by the field intensities; in a light wave, this energy of the field must be conceived to flow or spread out with the wave, i.e., with the speed of light.

523. Maxwell, speaking of the "analogy between light and (2.20) the vibration of an electric medium," says (in his early paper "On Faraday's Lines of Force") that "though its importance and fruitfulness cannot be over-estimated, we must recollect that it is founded only on a resemblance in form between the laws of light and those of vibrations."

Which of the following best expresses the meaning of this remark of Maxwell's?

A. The assumption that light is a wave phenomenon presupposes vibrations of an elastic medium; such an assumption can be tested only by examining its consequences and comparing them with the facts.
B. The conception of vibrations should be regarded, not as a physical theory to explain light, but a pictorial device to aid in understanding the laws of light.
C. The form of optical phenomena resembles that of wave phenomena, but the specific content (such as colors on the one hand, wave-length on the other) is different.
D. The laws of light correspond only in part to those of vibrations; in some respects, light behaves quite unlike vibrations of an elastic medium. Hence it is necessary to distinguish between a physical *theory* and a physical *analogy*.
E. The phenomena of reflection, refraction, diffraction and interference of light follow the same laws as the vibrations of an elastic medium; whether such a medium really exists as the cause of light is a further question which remains to be answered.

524. (2.20) Which of the following, according to Maxwell, is the chief importance of a "physical analogy"?

- **A.** It enables a familiarity with physical processes of one sort to serve as a guide in investigating other processes.
- **B.** It suggests a more general and powerful physical theory—that is, analogous phenomena (like electricity and magnetism) may be comprehended in a single theory.
- **C.** It enables a physicist to dispense with mathematical formulae.
- **D.** It enables a physicist to avoid committing himself to a theory before the evidence is conclusive.
- **E.** A physical analogy between two realms of phenomena may suggest a mathematical analogy between the formulae, or "laws," which they satisfy.

525. (2.20) Does it follow, from the proposition that charges on a conductor can reside only upon its surface, that an electric current cannot flow in the interior of a conductor?

- **A.** No, because that conclusion applies only to excess positive or negative charges in equilibrium; an excess positive or negative charge can occur within a conductor, but it will then flow; and currents can exist even in the absence of an excess charge.
- **B.** Yes, because a current is a flow of charge, and where no charge exists no current can occur, whether there is "equilibrium" or not.
- **C.** No, because the proposition cited does not speak of currents, but only of charges and the term "charge" refers to electricity at rest.
- **D.** Yes, because positive and negative charges mixed in equal amounts cannot produce a current, since even if the charge were to flow, the "positive current" and "negative current" would cancel one another out.
- **E.** No, because positive or negative charges can occur in excess within a conductor that is not in static equilibrium; however, as long as no excess charges occur, currents are impossible.

According to the theory of electrical conduction in metals that was developed by Lorentz and Drude in the late nineteenth and early twentieth century, currents in metals consist exclusively of streams of the negatively charged particles called "electrons," while positive charges in the metal cannot move.

526. (2.20) This situation could be expressed by saying that a metallic conductor has

- **A.** zero resistance to negative electricity.
- **B.** infinite resistance to negative electricity.
- **C.** infinite resistance to positive electricity.
- **D.** zero resistance to positive electricity.
- **E.** zero resistance to negative, infinite resistance to positive electricity.

527. (2.20) According to this theory of metallic conduction, two wires carrying currents

- **A.** should show electrostatic repulsion because of the negative charges, and stronger repulsion the greater the current.
- **B.** should show electrostatic repulsion, but not necessarily in proportion to the current, since greater current might be produced either by more negative charge or the same charge moving faster.
- **C.** should show electrostatic repulsion, but its magnitude should be constant and independent of the current, since it is to be assumed that the number of electrons in a metal is fixed.
- **D.** need not have any electrostatic effects, since they may or may not have equal quantities of negative and positive charges; the motion of the negative charges is irrelevant to the occurrence of static attraction or repulsion.
- **E.** could not show electrostatic attraction or repulsion, since static effects are not exerted by moving charges.

528. (2.20) If an electroscope is to be used, not merely to detect, but to measure electric charges, it is useful to connect its gold-leaves to a conducting container, and to place the charges to be measured within the container. The utility of this arrangement comes from the fact that

- **A.** it shields the electroscope from the effects of charges other than those to be measured.
- **B.** it makes the response of the electroscope independent of the position of the charged body.
- **C.** it results in charges of opposite sign diminishing one another's effect upon the electroscope.
- **D.** it is the arrangement used in the definition of the quantative measure of charge.
- **E.** it gives the value of the charge directly in electrostatic units.

529. (2.30) The force on a magnetic pole at the center of a circular turn of wire is 20 dynes. If the radius of the turn is halved and the current in it is doubled, the force on the pole in dynes equals

A. 5. **B.** 10. **C.** 20. **D.** 40. **E.** 80.

In each of the following items blacken the answer space which corresponds to the letter of the one physical principle which is characteristic of the operation of the device or instrument given in each item.

- **A.** A force is exerted in a wire carrying an electric current, which has been placed in a magnetic field.
- **B.** Electrons are ejected from metals when heated to very high temperature.
- **C.** Electrons are ejected from metals when radiation of suitable wave lengths is incident on them. (Light falls on the metals.)
- **D.** An electric current is produced in a coil of wire whenever the magnetic field through the coil changes.

530. (2.40) Radio tube.

531. (2.40) Electric motor.

532. (2.40) Photoelectric cell.

533. (2.40) Galvanometer or ammeter.

534. (2.40) Electric generator.

Items 535 - 538. Choose from the key the information most helpful in explaining the operation of the devices listed.

KEY

- **A.** An emf. is induced in a conductor whenever it cuts magnetic lines of force.
- **B.** A force is exerted on a conductor carrying an electric current when placed in a magnetic field.
- **C.** Electrical potential is developed between two dissimilar metals placed in an acid solution.
- **D.** Metals heated to high temperature emit electrons.
- **E.** Certain metals exposed to radiation of suitable wave length emit electrons.

535. (2.40) Galvanometer.

536. (2.40) Photoelectric cell.

537. (2.40) Electric motor.

538. (2.40) Radio tube.

539. (2.40) According to the theory of electrostatics, a charge on a conductor must reside entirely upon its surface. This conclusion follows directly from

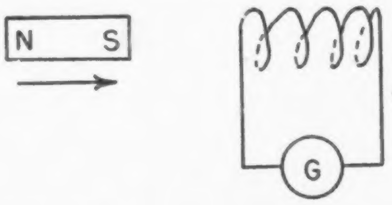
A. the fact that electricity can move through conductors.
B. the two principles, that lines of force begin and end upon charges and that lines of force cannot occur within a conductor in equilibrium.
C. the conception of a conductor as containing, in its interior, equal quantities of both kinds of charge, the two kinds being capable of being separated when the conductor is under induction.
D. the fact that every conductor has a finite resistance.
E. Joule's law of heating, together with the principle of the conservation of energy.

540. (2.40) The distinction of two kinds of electric charge, positive and negative, is a consequence of

A. the mathematical formulation of Coulomb's Law, in which the value of the charge may be positive or negative.
B. the distinction of bodies into two classes, conductors and insulators.
C. the fact that charges can be produced by friction, which suggests that the two charges so produced must be opposite.
D. the fact that the behavior (attraction or repulsion) of a charge toward all other charges is found to show one of the only two possible patterns.
E. the fact that some charged bodies attract and others repel one another.

Select the completion which makes the statement correct.

541. (3.00) Applying the left hand rule, we find that the magnetic field of the coil in the diagram has________on the left.



A. a north pole. **B.** a south pole. **C.** either pole.

542. (3.00) When the magnet is pulled away to the left, electrons at X will move

A. up. **B.** down. **C.** not at all.

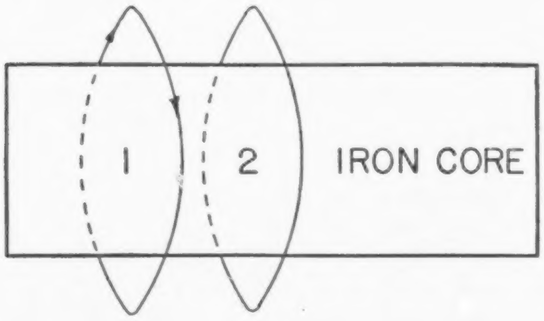
543. (3.00) This diagram illustrates

A. Voltmeter. **B.** Galvanometer. **C.** Ammeter.
D. Lenz's law. **E.** Coulomb's law.

544. (3.00) To induce a constant current having only one direction in a closed loop of wire is

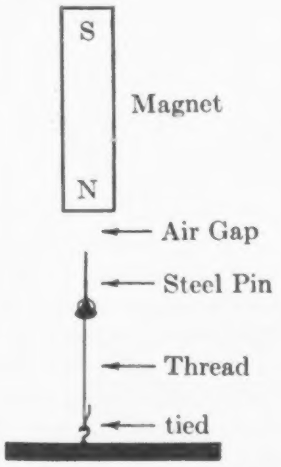
A. a very simple matter. **B.** practically impossible.
C. difficult but commonly done in laboratory work.
D. not simple but accomplished in every A.C. generator.
E. accomplished 100% in all D.C. generators.

545. (3.00) In the diagram, a current is induced in coil 2 whenever the current in coil 1 is increasing or decreasing. If the current in coil 1 is turned off, the induced current in coil 2 will



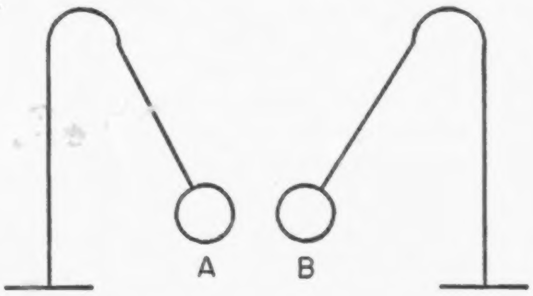
A. disappear instantly. **B.** be unchanged.
C. be in the same direction as the inducing current.
D. be in the opposite direction to the inducing current.
E. be independent of the number of turns of wire in coil 2.

546. (3.00) If thin plates of the following are inserted in the air gap in the diagram, which one would cause the pin to fall?



A. Glass. **B.** Copper. **C.** Mica.
D. Aluminum. **E.** Iron.

547. (3.00) Two charged pith balls (see diagram) A and B are brought near one another and found to attract strongly. When a negatively charged rod is brought near ball B, the ball is repelled. Ball A must be

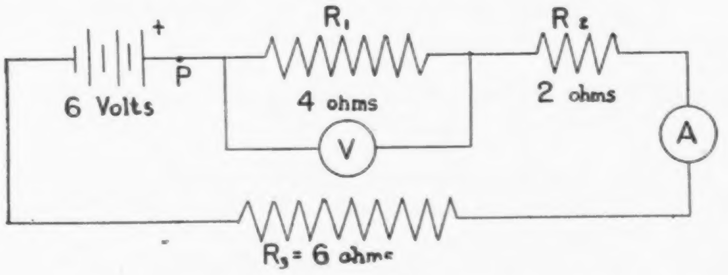


A. negatively charged. **B.** uncharged.
C. positively charged.
D. there is insufficient information to determine the charge on the ball.

548. (3.00) A person using a 250 watt electric heater wanted to keep the expense down to 10 cents per day. The maximum number of hours he could use it at the rate of 4 cents per kilowatt-hour is

A. 10. **B.** 20. **C.** 2.5. **D.** 4. **E.** 6.25.

549. (3.00) A student connected three resistances, a voltmeter, and an ammeter to a six volt battery as shown in the diagram.



Assume he desired to measure the current through R_1 and the voltage across R_1.

- **A.** He should interchange R_2 and A.
- **B.** He should place the ammeter A in the circuit at the point P.
- **C.** He should interchange V and A.
- **D.** He should interchange R_3 and A.
- **E.** He need not change anything in the diagram.

550. (3.00) If the circuit is used as shown, the ammeter will read

A. .25 ampere. **B.** .75 ampere. **C.** 1.5 amperes. **D.** 2.0 amperes. **E.** none of these.

Suggestion: Ohm's Law states that the current is directly proportional to the voltage and inversely proportional to the resistance.

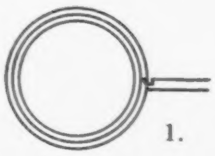
551. (3.00) If the circuit is used as shown, the voltmeter will read

A. ½ volt. **B.** 1 volt. **C.** 2 volts. **D.** 3 volts. **E.** none of these.

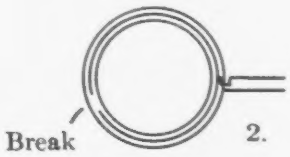
552. (3.00) An electric toaster is stamped 200 watts and is used on 110 volts. If the cost of operating the toaster is $0.05 per kilowatt hour, the cost to operate it for 15 minutes a day for 30 days will be

A. $.08. **B.** $.83. **C.** $.33. **D.** $3.50. **E.** $8.25.

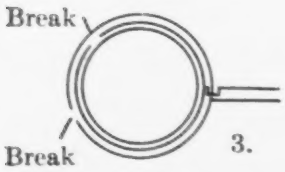
553. (3.00)



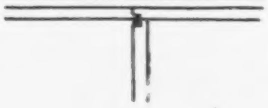
1.



2.



3.



4.

A toy electric train runs on a metal track. One wire from the current source is attached to the middle or "third" rail and the other wire to one of the rails on which the wheels run. These two rails are insulated from one to another. The train picks up current from the third rail and returns it through this other rail. In which case diagrammed above will the circuit be such that the train will run?

- **A.** Track joined as a circle with no breaks in third or outer rails.
- **B.** Track joined as a circle but with one break in the third rail.
- **C.** Tracks joined as a circle with a break in both the third and outer rails in different sections of the track (i.e., breaks not opposite each other).
- **D.** Track laid out so that ends do not join to form a circle.
- **E.** In all of the above cases the train will run.

Items 554 - 556. Choose from the key the information most helpful in explaining the situations given in the items.

KEY

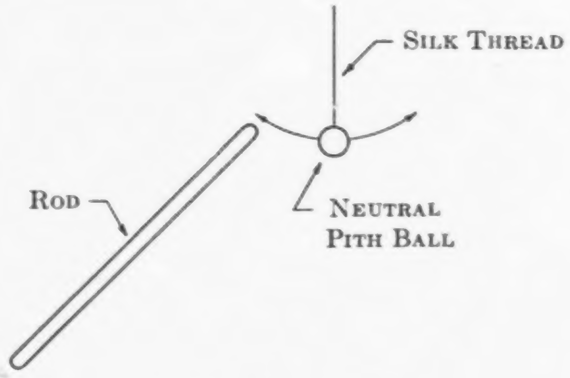
- **A.** The intensity of electron flow in an electrical current is equal to the electromotive force divided by the resistance of the conductor.
- **B.** The quantity of heat developed by an electric current equals the product of the square of the current, the resistance of the conductor, and the time.
- **C.** The force acting upon two charged bodies is equal to the product of their charges divided by the product of the conductivity of the medium separating them and the square of the distance between them.
- **D.** Electrical power is equal to the product of the current and the voltage.
- **E.** Electrical current is equal to the quantity of flow per unit of time.

554. (3.00) House lights are momentarily dimmed when electrical ranges or other heating elements are plugged in.

555. (3.00) A fuse can carry only a limited current.

556. (3.00) Electrical power can be transmitted at very high voltages more efficiently than at low voltages.

Items 557 - 562. Use the following sketch and key.



KEY

- **A.** Attracted and charged positively.
- **B.** Repelled and charged positively.
- **C.** Attracted and charged negatively.
- **D.** Repelled and charged negatively.
- **E.** Neither attracted nor repelled.

557. (3.00) If the pith ball shown in the sketch is touched by a glass rod which had been rubbed with silk, it would then be________.

558. (3.00) If then after once touching the pith ball, the glass rod is once again brought near the same pith ball, the pith ball would then be________.

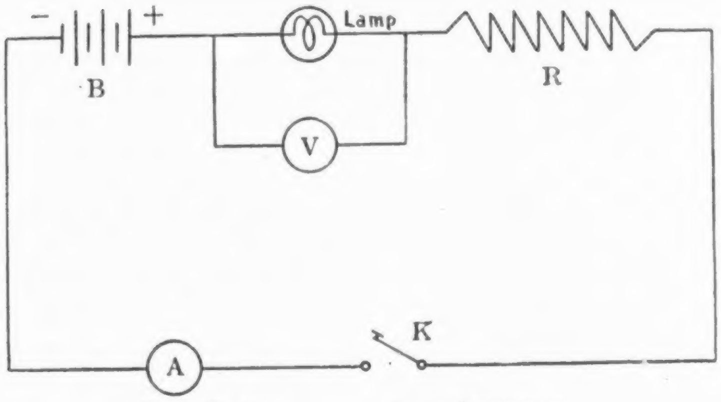
559. (3.00) However, if instead of a glass rod, a hard rubber rod which had been stroked with fur is brought near the same pith ball, the pith ball would probably be ________.

560. (3.00) If a new pith ball is touched by a hard rubber rod which had been stroked with fur, the pith ball would then be________.

561. (3.00) If after once touching the pith ball, the hard rubber rod is once again brought near the same pith ball, the pith ball would then be________.

562. (3.00) However, if instead of the hard rubber rod, a glass rod which had been rubbed with silk is brought near this same second pith ball, the pith ball would then be________.

563. (3.00) A student presented the following diagram to an instructor for approval before attempting to measure the current through a miniature lamp and the voltage or potential difference across the lamp.



B = Battery
L = Lamp
V = Voltmeter
A = Ammeter
R = Resistance
K = Key

The instructor's comment to the student should be:

A. Interchange B and V. **B.** Interchange A and V.
C. Interchange R and V. **D.** Interchange R and A.
E. The diagram is correct.

564. (3.00) If the student used the diagram as shown, the current through the lamp would be

A. less than the current through the battery.
B. more than the current through the resistance R.
C. less than the current through the resistance R.
D. equal to the current through the resistance R.
E. unrelated to the current through the resistance R.

565. (3.00) If the current through the lamp is .5 amperes when the voltage across the lamp is 5 volts, the resistance of the lamp is

A. 2.5 amperes. **B.** 4.5 amperes. **C.** 5.5 amperes.
D. 10.0 amperes. **E.** none of these.

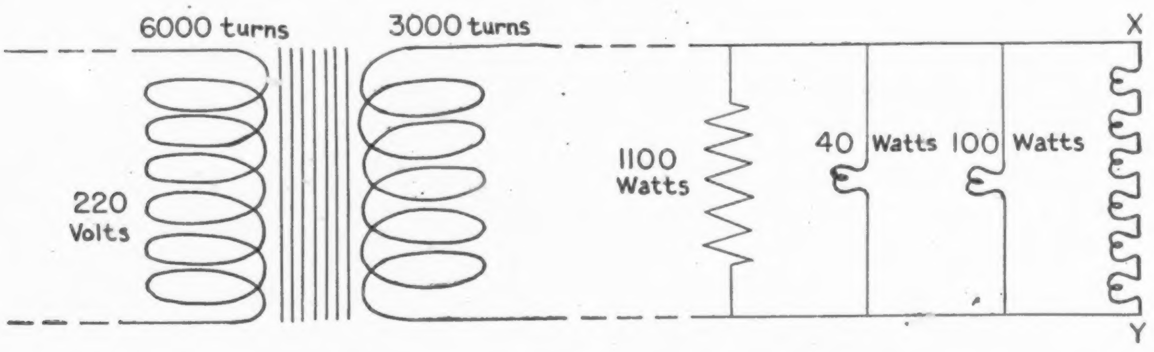
566. (3.00) The resistance of a circuit carrying an alternating electric current may be increased appreciably by

A. inserting a fuse
B. increasing the diameter of the conductor.
C. shortening the connecting wires.
D. increasing the voltage. **E.** a loose connection.

Items 567 - 570 refer to Diagram C showing a transformer and a portion of a typical home lighting circuit. Some of the following equations may be useful.

$$P = VI \qquad I = \frac{V}{R} \qquad H = .24I^2Rt$$

Diagram C



567. (3.00) The 100 watt lamp bulb

A. has more resistance than the toaster.
B. has a greater potential difference across it than the 40 watt bulb.
C. is in series with the toaster.
D. reaches a lower internal temperature than the toaster.
E. has greater resistance than the 40 watt bulb.

568. (3.00) When the toaster is in use, the current used is

A. 1 ampere. **B.** 5 amperes. **C.** 10 amperes.
D. 11 amperes. **E.** 1/10 amperes.

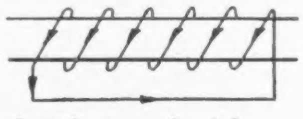
569. (3.00) When the current in the house circuit is 10/11 amperes, the current in the primary of the transformer is approximately

A. 5/11 amperes. **B.** 20/11 amperes.
C. 10/11 amperes. **D.** 110 amperes.
E. none of the above.

570. (3.00) If x to y represents a string of old style Christmas lights,

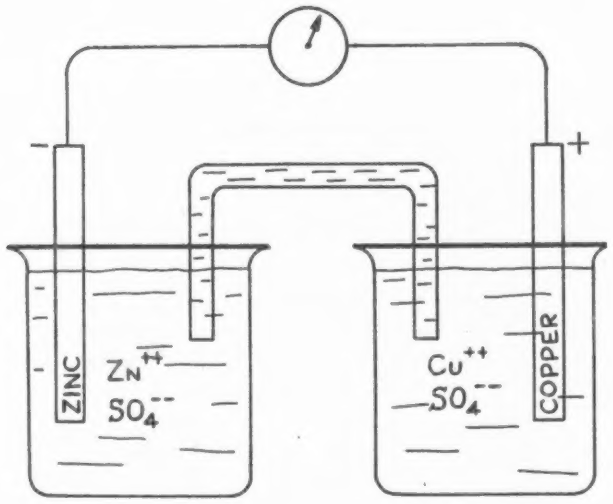
A. the voltage across each of the lamps is 110 volts.
B. the lights are connected in parallel with each other.
C. the resistance from x to y is less than the resistance of a single lamp.
D. the current through each one of the lamps is the same.
E. the electron flow is from x to y only.

571. (3.00) The direction of flow of electrons in a coil about an iron core is indicated below. Under these conditions



A. the North Pole is at the left.
B. the South Pole is at the left.
C. both poles are at the left.
D. there are no poles formed.

Items 572 - 578. After each item number on the answer sheet, blacken space



A. if the item is true of atoms of copper in the copper electrode.
B. if the item is true of copper ions in the Cu^{++}, SO_4^{--}.
C. if the item is true of zinc ions in the Zn^{++}, SO_4^{--} solution.
D. if the item is true of zinc atoms in the zinc electrode.
E. if the item is true of the SO_4^{--} ions.

572. (3.00) Substance which releases the electrons.

573. (3.00) Ions which gain electrons and which are deposited as neutral atoms.

574. (3.00) Atoms which give up electrons and form positive ions.

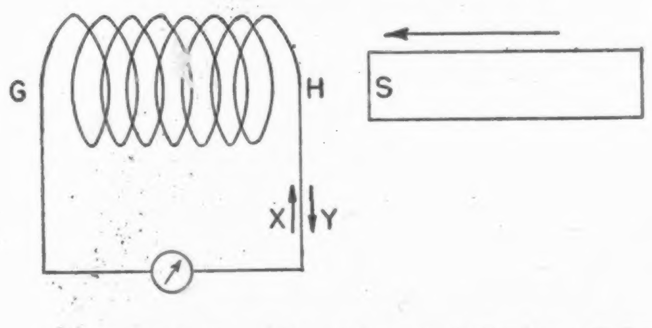
575. (3.00) Ion whose concentration does not change.

576. (3.00) Ion whose concentration increases as the cell is in operation.

577. (3.00) Ion whose concentration decreases as the cell is in operation.

578. (3.00) The answer listed above which refers to the metal higher in the electrochemical series.

579. (3.00) A bar magnet is thrust into a coil of wire as indicated in the diagram. Which of the following statements concerning this experiment is completely correct?



A. The polarity of the coil at H is North, at G South, and the direction of the induced current is indicated by arrow X.
B. The polarity of the coil at H is South, at G North, and the direction of the induced current is indicated by arrow X.
C. The polarity of the coil at H is South, at G North, and the direction of the induced current is indicated by arrow Y.

580. (3.00) A shunt motor is running on a 120-volt line. The armature current is 10 amperes and the back e.m.f. in the armature is 115 volts. This shows that the armature resistance is

A. 2 ohms. **B.** 5 ohms. **C.** 12 ohms.
D. 0.5 ohms. **E.** 1.15 ohms.

For items 581 and 582 choose your answers from the lettered list below each question.

581. (3.00) A safe place in an electric storm is

1. on a wide open golf course.
2. in a sail-boat.
3. in a steel and concrete building.
4. in a modern automobile.
5. under a tall tree.

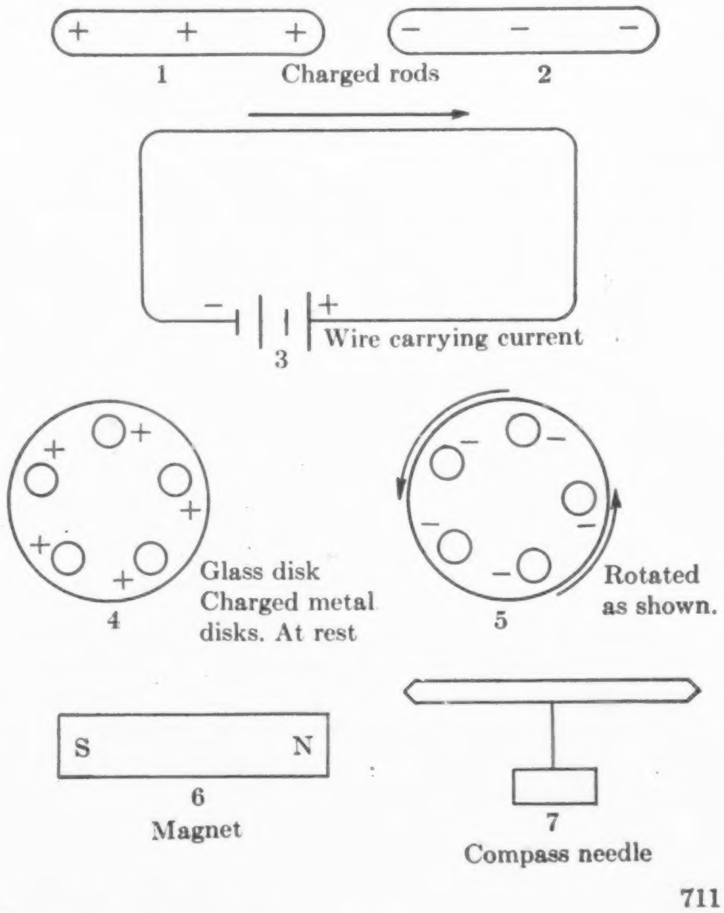
A. 1 and 2. **B.** 3 and 4. **C.** 4 and 5.
D. 2 and 4. **E.** All of these.

582. (3.00) A man in a wire cage holding an uncharged electroscope and sitting in an insulated chair may charge the electroscope by

1. connecting the cage to a battery.
2. having lightning strike the cage.
3. bringing the electroscope knob near a flame or hot nail.
4. rubbing a comb against his wool sleeve and touching the electroscope knob with the comb.
5. connecting the cage to a source of alternating current.

A. 1 only. **B.** 5 only. **C.** 4 only. **D.** 1 and 3.
E. 2 and 3.

Items 583 - 589 refer to the following diagram. After each exercise number on the answer sheet, blacken the one lettered space which designates the correct answer.



583. (3.00) In which of the following combinations of these devices would each device affect the compass needle if each were brought near to the needle?

A. 1, 2, and 4. **B.** 2, 3, and 4. **C.** 3, 5 and 6.
D. 3, 4 and 5. **E.** 4, 5 and 6.

584. (3.00) Which of the following pairs of these devices could be used in repeating Oersted's famous experiment concerning the magnetic effect of an electric current?

A. 1 and 3. **B.** 2 and 3. **C.** 3 and 5.
D. 3 and 7. **E.** 4 and 7.

585. (3.00) Which of the following sets of devices could be used in repeating Rowland's famous experiment showing that a moving charge is, in effect, an electric current, while a charge at rest is not?

A. 1, 2 and 7. **B.** 4, 5 and 7. **C.** 4, 5 and 6.
D. 2, 3 and 7. **E.** 3, 4 and 5.

586. (3.00) Which of the following pairs of these most nearly resemble each other?

A. 1 and 7. **B.** 6 and 7. **C.** 2 and 7.
D. 1 and 6. **E.** 2 and 6.

587. (3.00) In which of the following sets of devices has each device been or is concerned with electrons in motion?

A. 1, 2 and 3. **B.** 1, 2 and 6. **C.** 1, 2 and 7.
D. 1, 3 and 6. **E.** 3, 6 and 7.

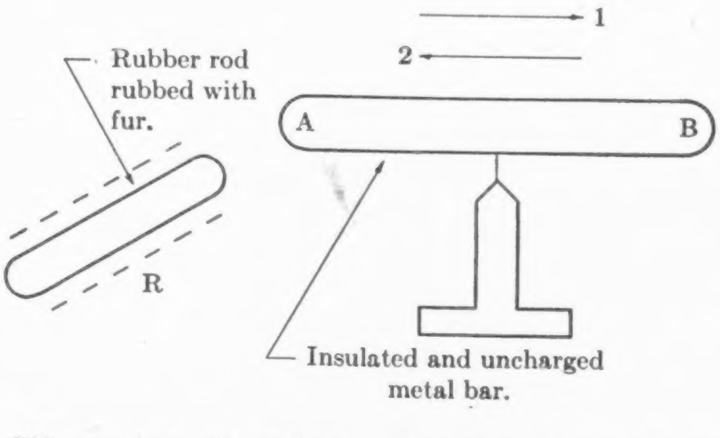
588. (3.00) Which of the following pairs of devices would tend most to attract each other if brought together?

A. 4 and 5. **B.** 1 and 6. **C.** 2 and 6.
D. 1 and 2. **E.** 4 and 6.

589. (3.00) Which of the devices listed below would have the greatest tendency to place itself in a definite direction in the earth's magnetic field?

A. 1. **B.** 2. **C.** 6. **D.** 7. **E.** 4.

Items 590 - 594 refer to the following diagram. After each exercise number on the answer sheet, blacken the *one* lettered space which designates the correct answer.


1
2
Rubber rod rubbed with fur.
A
B
R
Insulated and uncharged metal bar.

590. (3.00) As the result of the presence of the rod near the bar

A. negative charges move in direction *1*.
B. negative charges move in direction *2*.
C. positive charges move in direction *1*.
D. positive charges move in direction *2*.
E. both positive and negative charges move in opposite directions.

591. (3.00) As a result of the presence of the rod near the bar, the bar is

A. − at end A and − at end B.
B. − at end A and + at end B.
C. + at end A and − at end B.
D. + at end A and also + at end B.
E. entirely neutral.

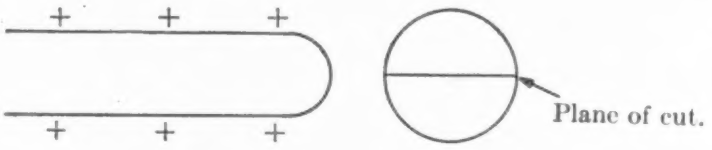
592. (3.00) As the result of the presence of the rod, the bar is

A. attracted and turns toward the rod R.
B. repelled and turns away from the rod R.
C. not effected.

593. (3.00) If the rod R, had been of glass and rubbed with silk, and brought near the bar,

A. the bar would have been attracted to the rod.
B. the bar would be repelled by the rod.
C. there would be no effect on the bar.

594. (3.00) With the glass rod R *positively* charged and held near a neutral sphere, the sphere is cut in half horizontally with an insulated saw.



When the glass rod is removed

A. upper half is positive, the bottom half negative.
B. upper half is negative, the lower half positive.
C. both halves are positive.
D. both halves are negative.
E. both halves are neutral.

Items 595 - 597 refer to the following data. An electric water heater (a suitable coil of wire) is immersed in a vessel containing 800 gm. of water at 20°C. and a potential difference of 110 volts is applied. The water begins to boil in 5 minutes. The heat capacity of the vessel and loss due to radiation can be neglected. Use any of the following formulas that may be needed.

1 cal. = 4.18 joules. $P = VI$ $E = IR$ $W = VIt$

595. (2.10) The power applied is approximately

A. 215 watts. **B.** 640 watts. **C.** 890 watts.
D. 1070 watts. **E.** none of these.

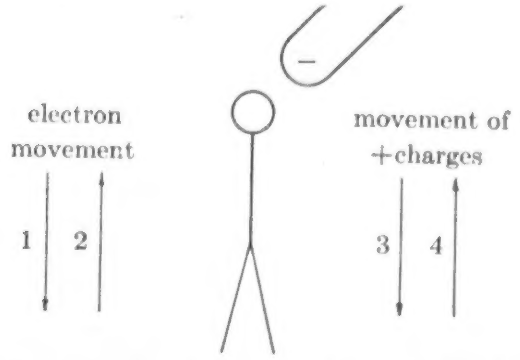
596. (3.00) If we wished to double the applied power, we would most likely

A. double the resistance of the coil.
B. double the time of operation of the coil.
C. halve the amount of water used in the vessel.
D. halve the resistance of the coil.
E. halve the current through the coil.

597. (2.10) If the current through the coil is approximately 8 amperes, the resistance of the coil is approximately

A. 8.1 ohms. **B.** 9.9 ohms. **C.** 12.1 ohms.
D. 13.5 ohms. **E.** none of these.

598. (3.00) A negatively charged rubber rod is brought near to, but does not touch, the knob of an uncharged electroscope.



A. There is no effect on the leaves of the electroscope.
B. The leaves diverge with a positive charge resulting from electron motion shown as 2.
C. The leaves diverge with a negative charge resulting from motion 1.
D. The leaves diverge with a positive charge from motion shown as 3.
E. The leaves diverge with a negative charge from motion shown as 4.

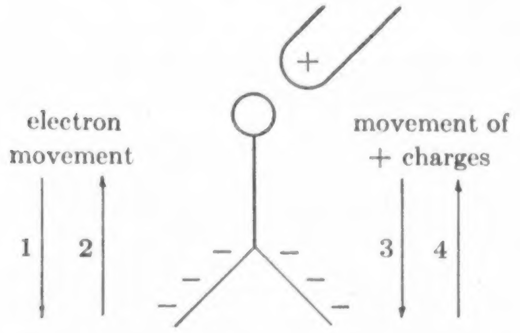
599. (3.00) The grounding of the electroscope as shown in the previous item and subsequent removal of the negatively charged rubber rod, results in the electroscope now having

A. a positive charge. **B.** a negative charge.
C. no charge.

600. (3.00) A positively charged glass rod is brought near to, but does not touch, the knob of a negatively charged electroscope.

A. The leaves collapse from motion 3.
B. The leaves diverge further from motion 4.
C. The leaves diverge still further from motion 1.
D. The leaves collapse from motion 2.

601. (3.00) A negatively charged rubber rod is brought near, but not touching, the knob of the electroscope in the previous item. Possible motions are also as shown in this item.

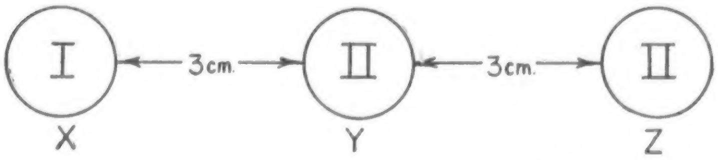


A. The leaves collapse from motion 3.
B. The leaves diverge further from motion 4.
C. The leaves diverge still further from motion 1.
D. The leaves collapse from motion 2.

602. (3.00) The slow collapse of the leaves of a negatively charged electroscope is most likely to result from the transfer on contact of

A. positive charges from air ions to the knob.
B. electrons from the knob to neutral air molecules.
C. positive charges from neutral air molecules.
D. electrons from negative air ions to the knob.
E. electrons from the knob to positive air ions.

Items 603 and 604 refer to the following diagram.



603. (3.00) Bodies I and II are given unlike charges, are in positions X and Y so the charge may not leak off. Body II is now moved from position Y to position Z. The force between I and II will now be

A. unchanged. **B.** one-fourth as great.
C. one-half as great. **D.** twice as great.
E. four times as great.

604. (3.00) Bodies I and II when in position X and Z are given equal like charges of electricity. Body I is now moved to position Y. The force between the bodies will now be

A. unchanged. **B.** one-fourth as great.
C. one-half as great. **D.** twice as great.
E. four times as great.

605. (1.10) When a "short circuit" develops in a lamp cord, or other device, through a break in the insulation, there is

A. an increase in the resistance of the circuit.
B. a decrease in the resistance of the circuit.
C. no change in the resistance of the circuit.

606. (1.10) The short circuit mentioned in item 605 results in a

A. large increase of the current in the circuit.
B. decrease of the current in the circuit.
C. large increase in the voltage in that part of the circuit.
D. decrease in the voltage in that part of the circuit.

607. (1.10) The short circuit mentioned in item 605, but in a circuit *not* protected by a fuse, results in a

A. large temperature change in all parts of the circuit.
B. small temperature change where the "short" occurs.
C. negligible change in temperature in all parts of the circuit.

608. (1.10) If the circuit is protected by a fuse, the short circuit results in

A. an appreciable change in temperature in all parts of the circuit.
B. an effective change in temperature in the fuse only.
C. a continued flow of current in the circuit.
D. a decrease in the resistance of the circuit.

609. (1.10) The change mentioned in item 608 also

A. melts the fuse and opens the circuit.
B. melts the fuse and closes the circuit.
C. usually leaves the fuse unaffected.

Items 610 - 615. After each item number on the answer sheet, blacken space

A. if the item refers to North-seeking poles (N).
B. if the item refers to South-seeking poles (S).
C. if the item is true of both types of poles.
D. if the item is true of neither type of pole.

610. (1.10) End of the compass needle which points to a spot just south of Melbourne, Australia.

611. (1.10) End which points to a spot north and east of Hudson's Bay in Canada.

612. Possessed by every magnet.
(1.10)

613. Always points directly toward the north geographic pole.
(1.10)

614. End of the compass needle commonly considered in navigation.
(1.10)

615. Possessed by a stationary body which has been given an electrostatic charge only.
(1.10)

Items 616 - 620. A heater element is rated to pass 5 amperes when connected to 120-volt mains.

616. In operation the element loses heat at the rate of
(3.00)

A. 5. **B.** 24. **C.** 120. **D.** 600. **E.** 3000.

617. The unit of this rate of loss of heat is
(1.10)

A. e.s.u. **B.** erg. **C.** watt. **D.** calorie.
E. joule.

618. The resistance of the element in ohms is
(3.00)

A. 5. **B.** 24. **C.** 120. **D.** 600. **E.** 3000.

619. The work done on 5 coulombs on passing them through the element is of magnitude
(3.00)

A. 5. **B.** 24. **C.** 120. **D.** 600. **E.** 3000.

620. The unit of this work is
(1.10)

A. e.s.u. **B.** erg. **C.** watt. **D.** calorie.
E. joule.

621. A belt-driven electric generator is charging a storage battery. When the belt breaks
(3.00)

A. the armature stops. **B.** the armature speeds up.
C. the circuit breaker opens.
D. the armature continues to rotate in the same direction.
E. the armature rotates in the opposite direction.

622. A magnet is 5 cm. long and has a pole strength of 5 unit poles. At a point 5 cm. from the south pole on a line through the north and south poles, the magnetic field intensity in dynes per unit N pole is
(3.00)

A. 0.5 toward magnet. **B.** 0.5 away from magnet.
C. 0.15 toward magnet. **D.** 0.15 away from magnet.
E. 0.25 toward magnet.

Item 623 deleted.

624. Points A and B are 100 cms. apart and point B is 200 e.s.u. of potential higher than point A. The work done on 4 e.s.u. of charge in carrying them from A to B is
(3.00)

A. 0.04 erg. **B.** 0.08 erg. **C.** 2 ergs.
D. 8 ergs. **E.** 800 ergs.

Items 625 and 626. Assume that the electromotive force of a gravity cell is 1.0 volt and that its resistance is 4.0 ohms.

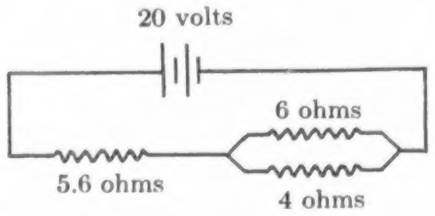
625. Twelve gravity cells are connected in series to a coil of 32 ohms resistance. The current flowing is
(3.00)

A. 20 amps. **B.** 15 amps. **C.** 2.5 amps.
D. 0.20 amp. **E.** 0.15 amp.

626. The potential difference at the terminals of the battery is
(3.00)

A. 2.4 volts. **B.** 4.8 volts. **C.** 9.6 volts.
D. 4.0 volts. **E.** 48 volts.

627. The resistance of the battery and connecting wires in the diagram is 2 ohms. The current in the circuit is
(3.00)



A. 1.28 amps. **B.** 1.08 amps. **C.** 4.72 amps.
D. 2.0 amps. **E.** 3.0 amps.

Items 628 - 629. A galvanometer with a coil of resistance 100 ohms shows full scale deflection when current of 0.1 ampere is passed through it. A resistance of 10 ohms is connected between the terminals of the galvanometer to form an electrical instrument.

628. The resulting instrument usually is used for measuring
(3.00)

A. current. **B.** power. **C.** potential drop.
D. work. **E.** e.m.f.

629. The full-scale deflection of this instrument in practical units equals
(3.00)

A. 0.01. **B.** 1.0. **C.** 1.1. **D.** 10. **E.** 11.

Items 630 - 635. In a shunt-wound D.C. generator field coils have a resistance of 200 ohms and the armature has a resistance of 4 ohms. Under operating conditions the generator delivers 7 amperes at 100 volts. Stray losses are negligible.

630. The current in the field coil has the magnitude
(3.00)

A. 0.49. **B.** 0.5. **C.** 7. **D.** 7.5. **E.** 25.5.

631. The armature current in amperes is
(3.00)

A. 0.49. **B.** 7. **C.** 7.5. **D.** 25. **E.** 25.5.

632. The generated e.m.f. in volts equals
(3.00)

A. 70. **B.** 125. **C.** 130. **D.** 180. **E.** 202.

633. The power loss in the field coils is
(3.00)

A. 48 watts. **B.** 50 watts. **C.** 130 kilowatts.
D. 192 watts. **E.** 9800 watts.

634. The power loss in the armature is
(3.00)

A. 1. **B.** 192 watts. **C.** 196 watts.
D. 225 watts. **E.** 2500 watts.

635. The efficiency of this generator is approximately
(3.00)

A. 22%. **B.** 61%. **C.** 63%. **D.** 72%. **E.** 78.5%.

Items 636 - 638. In a shunt-wound D.C. motor the field coils have a resistance of 200 ohms and the armature has a resistance of 10 ohms. When the motor is connected to 200-volt mains, the current into the motor is 6 amperes.

636. The current in the field coil in amperes is
(3.00)

A. 0.952. **B.** 1. **C.** 5. **D.** 20. **E.** 21.

637. The armature current in amperes is
(3.00)

A. 1. **B.** 5. **C.** 5.048. **D.** 20. **E.** 21.

638. The back e.m.f. in volts equals
(3.00)

A. 50. **B.** 100. **C.** 150. **D.** 200. **E.** 250.

639. When an inductance coil is connected to a 120 volt
(3.00) generator having a frequency of 60 cycles per second, the current in it is 6 amperes. The impedance of the coil has the magnitude

A. 3. **B.** 12. **C.** 20. **D.** 1200. **E.** 43,200.

640. The unit of impedance is
(1.10)

A. watt. **B.** henry. **C.** ohm. **D.** oersted.
E. farad.

641. A storage battery has an e.m.f. of 6 volts and internal
(3.00) resistance of 0.3 ohm. If the battery is charged with a current of 10 amperes, the e.m.f. which must be applied to the terminals is

A. 9 volts. **B.** 6 volts. **C.** 3 volts.
D. 20 volts. **E.** 30 volts.

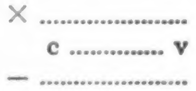
642. If the electron moves in the magnetic field only, its
(3.00) radius of curvature in cm. is

A. 1.42×10^{-9}. **B.** 12×10^{9}.
C. 9.54×10^{-10}. **D.** 23.85. **E.** 4.25.

643. If a magnetic field H is at right angles to the paper,
(3.00) the magnitude of H in e.s.u. required to just balance the electric force is

A. 1.33×10^{-9}. **B.** 12×10^{9}. **C.** 5.724.
D. 1.431. **E.** 23.85×10^{-19}.

644. An electron is travelling with a ve-
(3.00) locity $v = 3 \times 10^{9}$ cm./sec. between two metal plates 5 mm. apart and charged to 600 volts. (Charge on electron $= 4.77 \times 10^{-10}$ e.s.u. 300 volts $= 1$ e.s.u. and mass of electron $= 9 \times 10^{-28}$ gm.). The force on the electron due to this electric field is



A. 9.54×10^{-10} dynes. **B.** 19.08×10^{-10} dynes.
C. 14.31×10^{-10} dynes. **D.** 4.77×10^{-10} dynes.
E. 23.85×10^{-10} dynes.

645. A wire 5 cms. long with a current of 0.4 e.m.u. in it
(3.00) is placed at right angles to a uniform magnetic field of 200 lines of force per square centimeter. The force required to hold the wire in position equals

A. 80 dynes. **B.** 200 dynes. **C.** 400 dynes.
D. 800 dynes. **E.** 4000 dynes.

646. The force on a magnetic pole at the center of a cir-
(3.00) cular turn of wire is 20 dynes. If the radius of the turn is halved and the current in it is doubled, the force on the pole in dynes equals

A. 5. **B.** 10. **C.** 20. **D.** 40. **E.** 80.

Items 647 - 648. Assume that the electromotive force of a gravity cell is 1.0 volt and that its resistance is 4.0 ohms.

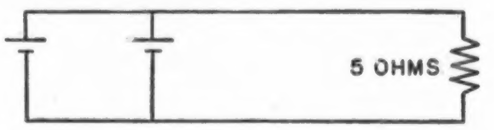
647. Twelve gravity cells are connected to a coil of 32 ohms
(3.00) resistance. The current flowing is

A. 20 amps. **B.** 15 amps. **C.** 2.5 amps.
D. 0.20 amps. **E.** 0.15 amps.

648. The potential difference at the terminals of the battery
(3.00) is

A. 2.4 volts. **B.** 4.8 volts. **C.** 9.6 volts.
D. 4.0 volts. **E.** 48 volts.

649. Each of two cells has an electromotive force of 6 volts
(3.00) and a resistance of 2 ohms. When they are connected to a 5 ohm resistor as shown, the amperes of current in the resistor is



A. $\frac{1}{2}$. **B.** $\frac{2}{3}$. **C.** 1. **D.** $\frac{4}{3}$. **E.** 2.

Items 650 - 651 deleted.

652. If an electroscope has been charged by touching it with
(3.00) a glass rod which has been rubbed with silk

A. a glass rod rubbed with silk brought close to the electroscope will cause the leaves to diverge still farther.
B. a hard rubber rod rubbed with flannel brought close to the electroscope will cause the leaves to diverge still farther.
C. a glass rod rubbed with silk brought close to the electroscope will cause the leaves to collapse.
D. an uncharged conductor brought close to the electroscope will have no effect on the leaves.
E. the hand brought close to the leaves will cause them to diverge still farther.

653. $CuSO_4 \rightarrow Cu^{++} + SO4^{--}$

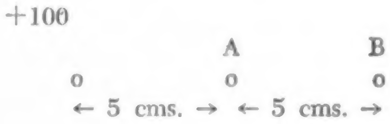
(3.00) $AgNO_3 \rightarrow Ag^{+} + NO_3^{-}$

If a current is sent through two cells in series, one containing copper sulphate ($CuSO_4$) solution and the other silver nitrate ($AgNO_3$) solution

A. the mass of copper deposited is twice that of the silver.
B. the number of atoms of copper deposited is twice that of the silver.
C. the same number of atoms of silver and copper are deposited.
D. twice as many atoms of silver as of copper are deposited.

654. Points A and B are 5 cms. and 10 cms. respectively
(3.00) from an electric charge of —100 e.s. units. When a charge of —5 e.s.u. is carried from B to A the work done is

A. 10 ergs.
B. 15 ergs.
C. 25 ergs.
D. 50 ergs.
E. 100 ergs.



655. If a cell of e.m.f. 1.5 volts and internal resistance 0.5
(3.00) ohm is connected to resistance of 2.5 ohms, the terminal voltage of the cell will be

A. 0 volt. **B.** 1.0 volt. **C.** 1.25 volt.
D. 1.5 volt. **E.** 2.5 volt.

656. A sensitive galvanometer has been converted to an
(3.00) ammeter for measuring currents up to ten amperes by means of a proper resistance placed in parallel with the galvanometer coil.

A. To produce a deflection of the needle to the end of the scale, the same current must now flow through the coil as was required to produce a full scale deflection of the galvanometer.
B. The parallel resistance must have a larger value than the resistance of the coil.
C. The resistance should have been placed in series with the coil.
D. This instrument could not be used to measure a current of five amperes.
E. The ammeter thus made cannot be used as a practicable instrument for accurate measurements, but is merely a make-shift.

Item 657 deleted.

Items 658 - 660. A current of ¼ ampere flows for 10 minutes through a resistance of 480 ohms.

658. The potential difference across the resistance is
(3.00)

A. 8 volts. **B.** 40 volts. **C.** 120 volts.
D. 400 volts. **E.** 480 volts.

659. The power loss is
(3.00)

A. 2 watts. **B.** 30 watts. **C.** 100 watts.
D. 120 watts. **E.** 480 watts.

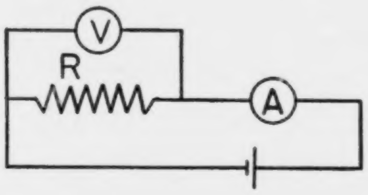
660. The energy loss is
(3.00)

A. 2 joules. **B.** 130 joules. **C.** 300 joules.
D. 3,000 joules. **E.** 18,000 joules.

661. A wire of resistance 4.2 ohms is connected to a cell of
(3.00) e.m.f. 1.5 volts. A voltmeter across the cell reads 1.4 volts. The internal resistance of the cell is

A. 0.3 ohm. **B.** 1/30 ohm. **C.** 1/3 ohm.
D. 0.42 ohm. **E.** 0.1 ohm.

662. In the diagram, A is an ammeter whose resistance is
(3.00) 0.5 ohm. It reads 5 amps. V is a voltmeter whose resistance is 20 ohms. It reads 20 volts. The resistance R is



A. 4 ohms. **B.** 5 ohms. **C.** 20 ohms.
D. 4.5 ohms. **E.** 3.5 ohms.

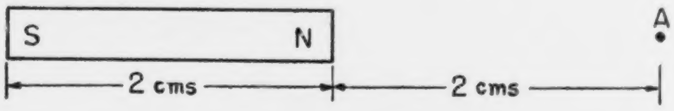
663. If a cell whose e.m.f. is 1.5 volts and internal resistance
(3.00) is 0.50 ohm is connected to a resistance coil of 2.5 ohms, the voltage across the terminals of the cell will be

A. 0 volt. **B.** 1.0 volt. **C.** 1.25 volts.
D. 1.50 volts. **E.** 2.50 volts.

664. If you look vertically down on the S pole of an upright
(3.00) electromagnet, the current in the coils must be flowing

A. south. **B.** clockwise. **C.** counter-clockwise.
D. upward. **E.** downward.

665. The diagram represents a magnet whose pole strength
(3.00) is m = 16 unit poles. The strength of the magnetic field at A is



A. 4 oersteds. **B.** 1 oersted. **C.** 1.5 oersteds.
D. 2 oersteds. **E.** 3 oersteds.

666. The direction of the field at A in the above diagram is
(3.00)

A to the left. **B.** to the right. **C.** up.
D. down. **E.** impossible to specify.

667. An ordinary electric clock designed to run on 60-cycle
(3.00) A.C. is connected at 12 o'clock noon to 30-cycle mains of proper voltage. After four hours the clock will read

A. twelve o'clock. **B.** two o'clock. **C.** four o'clock.
D. eight o'clock. **E.** half past one o'clock.

Items 668 and 669. A power company agrees to supply 22,000 watts to a certain consumer at 2200 volts. The transmission line between the power plant and the consumer has a total resistance of 5 ohms.

668. What effective current, in amperes, must be maintained
(3.00) in the transmission line?

A. 10. **B.** .1. **C.** 22. **D.** 440. **E.** 11,000.

669. At what voltage must the generator be operated if it
(3.00) supplies the line directly and is to supply 2200 volts to the consumer?

A. 2205. **B.** 2210. **B.** 2250. **D.** 2150.
E. 22,500.

670. If a wire through which a current is flowing is discon-
(3.00) nected from the source of potential difference that maintained the current, a "transient current" will continue to flow for a brief time, and to generate heat in the wire. The energy rise represented by the heat is compensated by

A. a continuation of the chemical processes in the cell for a short time after contact is broken.
B. the gradual disappearance of the charges carrying the current.
C. the loss in chemical energy of the cell just before contact was broken—i.e., there is an "energy lag," the disappearance of one kind of energy being compensated only after a time interval by the appearance of another kind.
D. the loss in energy accompanying the disappearance of the magnetic field as the current dies away.
E. a subsequent cooling of the wire.

671. A voltaic cell is used to maintain a current in a wire.
(3.00) When the current begins to flow, the temperature of the wire is observed gradually to rise. The source of the energy converted into heat in the wire is

A. the internal electric energy of the conducting wire.
B. the magnetic field of the current in the wire.
C. work done upon electric charges by chemical forces in the voltaic cell.
D. work done by electric charges against chemical forces in the voltaic cell.
E. heat generated by the chemical processes in the voltaic cell.

672. (3.00) When the current has flowed for some time, the temperature of the wire becomes constant. When this occurs

A. no energy is being converted into heat in the wire, and so no energy is being consumed to maintain the current.
B. energy is being consumed to maintain the current, but is not converted to heat in the wire; this energy must be radiated out from the moving charges constituting the current.
C. energy is being consumed as before, and converted to heat in the wire, but heat is flowing from the wire to its surroundings as fast as it is generated.
D. energy is being absorbed, so that the chemical processes which provided the energy of the current are not being reversed.
E. the magnetic field of the current may be expected to increase in intensity.

673. (3.00) Heating a metallic conductor might be expected to

A. impede the flow of an electric current, since the disorderly heat motion would tend to disrupt the orderly (unidirectional) flow constituting the current.
B. reinforce an electric current, since the current itself tends to heat the conductor.
C. reinforce an electric current, by providing a source of energy for the maintenance of the current.
D. produce an electric current, by setting electrons in motion.
E. impede the flow of an electric current, by breaking the conducting contact between adjacent atoms of the metal.

674. (3.00) It is observed that when body A, body B, body C or body D is placed near an electroscope, the leaves diverge. Body A repels B, attracts C and D. It can be predicted that

A. C will attract D, C and D will each repel B.
B. C will repel D, C and D will each repel B.
C. C will repel D, C and D will each attract B.
D. C will attract D, C and D will each attract B.
E. B will attract C and D; the mutual action of C and D cannot be predicted.

675. (3.00) Three bodies, A, B, and C, are observed to exert forces upon one another. Closer investigation reveals that A attracts B, B attracts C and C attracts A. Which of the following remarks is justified?

A. These observations are inconsistent with well-established physical laws, so that it is likely that they have been reported erroneously.
B. The forces observed suggest that A, B, and C might all have carried electric charges of the same sign.
C. The forces observed suggest that A, B, and C might all have carried electric charges of different signs.
D. The forces observed cannot be electrostatic in origin, but they might have come from some other source.
E. The forces observed may be electrostatic in origin, but they cannot be explained by assuming all three bodies to be charged.

676. (4.10) When the ratio of the charge to the mass (e/m) of the electron was calculated, which one of the following assumptions was made about the electron?

A. The charge on the electron was positive.
B. The electron was a material particle.
C. The electron had no weight.
D. The electron always moves with the velocity of light.
E. The charge on the electron was negative.

677. (4.10) The significance of the electromagnetic theory of *light* for the investigation of the structure of *matter* stems from the fact that the electromagnetic theory of light

A. postulates the existence of a kind of matter, the ether, as the carrier of light and also of electricity and magnetism.
B. provides an insight into the process of emission and absorption of light that can guide investigations of interactions of radiation and matter.
C. provides in part an alternative and corrective, in part a supplement, to the kinetic theory of heat.
D. implies the existence of the electron as a basic component of matter.
E. rejects the idea of action at a distance, and so raises serious questions about the forces that hold the atoms of bodies together.

678. (4.20) The idea that electric and magnetic effects are propagated through a medium, rather than exerted at a distance, had as its major consequence for the *investigation* of electricity and magnetism

A. that the knowledge of electromagnetism gained from experiment should be formulated, if possible, in terms of the structure of fields rather than the forces between charges.
B. the program of reducing the phenomena of electromagnetism to mechanical causes—i.e., of seeking to explain the observed phenomena solely in terms of matter and motion.
C. that the laws governing electric energy should be regarded as of more fundamental importance than those governing forces on charges.
D. that an experimental determination of the speed of propagation of electromagnetic effects should be sought.
E. that the force between a pair of charges must follow a more complicated law than that of Coulomb.

Items 679 - 683. Imagine a dispute between two men concerning the role of Coulomb's Law in the science of electricity: X maintains that the law is simply a "description" of the observed behavior of electric charges, Y that it is a "theory" of the mutual actions of charges.

For each of the following statements, blacken answer space

A. if it is a correct statement upon which stress might validly have been put by X in forming his opinion.
B. if it is an incorrect statement, belief in which might be involved in X's opinion.
C. if it is a correct statement upon which stress might validly have been put by Y in forming his opinion.
D. if it is an incorrect statement, belief in which might be involved in Y's opinion.
E. if it has no relevance to the difference of opinion of X and Y.

679. (6.20) Coulomb's Law formulates results obtained from measurements of the forces exerted upon one another by various charged bodies at various distances, and does not attempt to "explain" these forces.

680. (6.20) Coulomb's Law, taken together with the principle of the vector composition of forces, predicts the forces that would act in *any* electrostatic system, while experimental evidence for the law comes from measurements or other observations made in only a limited number of cases.

681. (6.20) Regardless of any theory of the ultimate origin of the forces between charges, Coulomb's Law remains an objectively accurate account of the relation of those forces to the magnitudes of the charges and their relative positions.

682. (6.20) Coulomb's Law can be made the basis for methods of measuring electric charges, since it asserts that the charge is proportional to the force that acts on it in a given situation.

683. (6.20) The formulation of Coulomb's Law as a result of experiments on electrostatic attractions and repulsions of pairs of charges, presupposes that the only factors which affect the forces exerted upon one another by two charges at rest are the magnitudes of the two charges and the distance between them.

21. *Sound, Acoustics, and General Wave Phenomena*

SOUND, ACOUSTICS, AND GENERAL WAVE PHENOMENA

Items 1 - 9. After each item number on the answer sheet blacken space

- **A.** if the blank would best be filled by the word "reflection."
- **B.** if the blank would best be filled by the word "refraction."
- **C.** if the blank would best be filled by the word "interference."
- **D.** if the blank would best be filled by the word "diffraction."
- **E.** if the blank would best be filled by the phrase "the Doppler effect."

1. (1.10) When water waves pass through a small opening in a breakwater, the waves going through become curved about the opening as a center. This is due to________.

2. (1.10) Whispering galleries bring sound to a focus by________.

3. (1.10) Reverberation is an example of multiple__________of sound.

4. (1.10) The apparent frequency of a sound depends on the relative velocity of the source and the observer. This is an example of________.

5. (1.10) A passenger in an airplane does not hear the same pitch of the engine as the friend he leaves behind at the airport because of________.

6. (1.10) Beats are due to________.

7. (1.10) Echoes are an example of________.

8. (1.10) Oil prospectors set off explosions to produce small earthquake waves. The________of these waves from rock strata underlying a flat surface enables the prospectors to locate the strata.

9. (1.10) It is said that the sound of guns fired in England can sometimes be heard on the Continent although ships in the Channel cannot hear them because of________.

Items 10 - 20. Blacken space

- **A.** if the item on the left is greater than that on the right.
- **B.** if the item on the right is greater than that on the left.
- **C.** if the two items are equal.

10. (1.10)	Velocity of sound in cold air.	Velocity of sound in warm air.
11. (1.10)	Extent to which the medium affects the velocity of sound.	Extent to which pitch affects the velocity of sound.
12. (1.10)	Extent to which pitch affects the velocity of sound.	Extent to which loudness affects the velocity of sound.
13. (1.10)	Probability of refraction of water waves in deep water.	Probability of refraction of water waves in shallow water.
14. (1.10)	Velocity of sound in air.	Velocity of sound in water.
15. (1.10)	Probability of reverberation in a carpeted room.	Probability of reverberation in a room with a cement floor.
16. (1.10)	The length of time it takes a bugle call to reach a distant mountain.	The time it takes for the echo of this call to return from the mountain to the bugler.
17. (1.10)	Frequency of sound issuing from a long organ pipe.	Frequency of sound issuing from a short organ pipe.
18. (1.10)	The pitch of a train's whistle to a passenger on the train.	The pitch of the same whistle to the station agent on the platform.
19. (1.10)	The wave length of middle C.	The wave length of high C.
20. (1.10)	The amplitude of a soft sound.	The amplitude of a loud sound of the same pitch.

For items 21 - 26, use the following key:

KEY

A. Fundamental. **B.** Overtone. **C.** Consonance.
D. Dissonance. **E.** Resonance.

21. (1.10) Sympathetic vibration is one form of________.

22. (1.10) A tuning fork in a room, when struck, causes a glass tumbler to vibrate. This illustrates________.

23. (1.10) The octave of a note is its first________.

24. (1.10) Two notes when played together sound unpleasant.

25. (1.10) In the preceding item, the tone having a frequency of 256 is________.

26. (1.10) Middle C (256) when sounded on a violin by a skilled player consists of various sounds among which is a note with a frequency of 512. This last note is________.

27. (1.10) A "C" note on a violin and a "C" note on a trumpet have a different quality to the ear because they differ in

- **A.** the amplitude of the sound wave.
- **B.** the number of overtones present.
- **C.** the frequency of vibration.
- **D.** the velocity of the sound wave.
- **E.** the pitch.

28. (1.10) Standing waves in strings or organ pipes may be set up when two waves

- **A.** of the same frequency and amplitude travel in opposite directions.
- **B.** alike in every other respect but opposite in phase travel in the same direction.
- **C.** of the same frequency and in phase with each other travel in the same direction.
- **D.** of slightly different frequency traveling in the same direction combine with each other.
- **E.** traveling in the same direction meet, one of which is double the frequency of the other.

29. (1.10) The number of overtones present and their intensity determine for a musical sound the

A. quality. **B.** pitch. **C.** amplitude.
D. frequency. **E.** loudness.

30. (1.10) A sound may travel faster in a given medium if

A. the frequency of vibration of the source is reduced.
B. overtones are present. **C.** the pitch is raised.
D. the amplitude of the sound is increased.
E. the temperature of the medium is increased.

31. (1.10) The velocity of sound is dependent upon all of these *except*

A. the energy used in producing the sound.
B. the amplitude of the wave.
C. the temperature. **D.** elasticity.
E. the density of the material propagating it.

Items 32 - 39 refer to wave motion. For each item select from the key the most appropriate response.

KEY

A. Light. **B.** Hertzian. **C.** Sound.
D. Two of the above. **E.** Three of the above.

32. (1.10) A wave showing diffraction effects.

33. (1.10) Particles vibrate in the direction of wave propagation.

34. (1.10) A wave which transmits energy.

35. (1.10) A wave with the narrowest range of wave lengths.

36. (1.10) A wave showing dispersive effects.

37. (1.10) A wave requiring no material medium for propagation.

38. (1.10) A wave with electromagnetic properties.

39. (1.10) A wave affected by temperature changes.

40. (1.10) Within a perfect vacuum there can be no evidence of

A. inertia. **B.** gravity. **C.** force.
D. static electricity. **E.** sound energy.

41. (1.10) Which one of these phenomena is the result of energy traveling in longitudinal waves?

A. Light. **B.** Sound. **C.** X-rays.
D. Cosmic rays. **E.** Electromagnetic radiation.

42. (1.10) Sound waves

A. transmit energy. **B.** are transverse.
C. have a velocity independent of the nature of the transmitting medium.
D. will travel through a vacuum.
E. do not show a diffraction effect.

43. (1.10) Noise differs from a musical tone largely in

A. velocity. **B.** intensity. **C.** regularity.
D. amplitude. **E.** frequency.

44. (1.10) Which one of the following phrases regarding wave motion defines amplitude?

A. The distance from a particle to the next successive one moving in the same phase.
B. The distance from a particle on the x axis to the next particle crossing the x axis.
C. The particle with the greatest displacement.
D. The distance between two successive particles moving in the same direction and having equal displacements at the same time.
E. The maximum distance a particle is displaced from its point of rest.

45. (1.10) In wave motion, when two waves interfere, there is *always* a change in

A. wave length. **B.** frequency. **C.** amplitude.
D. period. **E.** phase.

46. (1.10) Under comparable temperature conditions, a source produces sound waves at a certain velocity immediately above the earth. If the same source were transferred to a comparable position on the moon the velocity of the sound would

A. increase. **B.** decrease but not to zero.
C. remain unchanged. **D.** become zero.
E. be unpredictable.

For items 47 - 49 the key list presents references to the general properties of waves. Choose that property most useful in explaining the situations.

KEY

A. Reflection. **B.** Refraction. **C.** Interference.
D. Diffraction. **E.** The Doppler effect.

47. (1.10) The colors exhibited by soap and oil-film.

48. (1.10) Sounds may be heard at greater distances over water than over land.

49. (1.10) Sounds may be heard around the corners of objects that do not allow the sounds to pass through.

50. (1.10) Beats in sound refer to

A. the constructive interference of two wave forms.
B. the combination of two waves of slightly different frequency.
C. the fact that each point on a wave front acts as though it were a new source.
D. the bending of a wave front around the corner of an obstacle.
E. the effect when relative motion between the observer and the source of waves takes place.

Items 51 - 58 refer to wave motion. For each item select from the key the most closely related term.

KEY

A. Amplitude. **B.** Period. **C.** Phase.
D. Wave length. **E.** Frequency.

51. (1.10) The relationship of two identical waves.

52. (1.10) The displacement of a particle, in wave motion, when its velocity is equal to zero.

53. (1.10) The reciprocal of the period.

54. The velocity of a wave divided by its frequency.
(1.10)

55. The pitch of a sound wave is directly proportional to this term.
(1.10)

56. Constructive interference of two identical waves will double this term.
(1.10)

57. Loudness of a sound wave is considerably influenced by this term.
(1.10)

58. The distance between two successive particles executing the same motion.
(1.10)

59. Which one of these terms is *not* associated with sound waves?
(1.10)

A. Rarefaction. **B.** Material medium.
C. Transverse. **D.** Compressional.
E. Longitudinal.

Items 60 - 66 refer to definitions or applications of phenomena in wave motion. For each item select from the key the *most closely* related term.

KEY

A. Diffraction. **B.** Doppler effect.
C. Interference. **D.** Reflection. **E.** Refraction.

60. Reverberations in certain auditoriums.
(1.10)

61. A jeweler often uses this property to detect imitation diamonds.
(1.10)

62. The angle of incidence always equals another important angle.
(1.10)

63. Apparent changes in the wave length of light coming from beyond the solar system.
(1.10)

64. The bending of light around sharp corners.
(1.10)

65. The formation of a spectrum with a suitable optical prism.
(1.10)

66. A wave in which the wave particles vibrate in the direction the wave moves forward is characteristic of
(1.10)

A. Hertzian waves. **B.** light. **C.** sound.
D. all waves.

67. The essence of wave motion is
(1.10)

A. transfer of energy. **B.** movement of matter.
C. transformation of energy.
D. production of energy.
E. production of water waves.

68. A megaphone is effective in "carrying" the voice, because it
(1.10)

A. increases the amount of energy expended.
B. increases the velocity.
C. increases the number of vibrations.
D. prevents the vibrations from being dissipated in all directions.
E. prevents the Doppler effect from interfering with the transmission from the wave.

69. When plane water waves pass through a small opening in a breakwater the waves going through become curved about the opening as a center, because of
(1.10)

A. reflection. **B.** refraction. **C.** diffraction.
D. interference. **E.** Doppler effect.

70. Sound differs from light chiefly in
(1.10)

A. not being subject to diffraction.
B. that it is a compressional wave rather than a longitudinal wave.
C. that it does not require energy for its origin.
D. that it is a longitudinal wave instead of a transverse wave.
E. that it lacks amplitude.

71. Beats are a result of
(1.10)

A. reflection. **B.** refraction. **C.** resonance.
D. interference. **E.** diffraction.

72. The lowest note that a string can produce is
(1.10)

A. fundamental. **B.** octave. **C.** harmonic.
D. overtone. **E.** tone.

73. To vibrate sympathetically, tuning forks must have the same
(1.10)

A. composition. **B.** amplitude of vibration.
C. fundamental frequency.
D. physical dimensions. **E.** harmonics.

74. The rise of pitch of an approaching or receding siren is due to an apparent increase in the
(1.10)

A. velocity. **B.** amplitude. **C.** frequency.
D. quality. **E.** resonance of sound.

75. The average human ear is most sensitive to frequencies of approximately 2000 vibrations per second because
(1.10)

A. this represents the lowest frequency of perception of the normal ear.
B. the human sensory mechanism is so constituted that it perceives this frequency most easily.
C. this represents the highest frequency of perception of the normal ear and the higher frequencies have higher energies.
D. this is the only frequency which the ear perceives.
E. this frequency possesses the greatest energy.

76. If the pilot of a jet plane traveling faster than 1200 feet per second were to drop a bomb, he would
(1.10)

A. never hear the explosion.
B. hear a lower tone than an observer on the ground.
C. hear a higher tone than the observer on the ground.
D. hear the sound and then see the explosion occur.

77. The conductor of a symphony orchestra brings down his baton and both the piccolo player and the bass fiddle player start playing at the same instant. To an observer in the gallery
(1.10)

A. the high tones of the piccolo are heard first.
B. they are both heard at the same time.
C. the low tones of the bass are heard first.
D. there are insufficient data to determine this properly.

78. The correct answer to item 77 above was selected because
(1.10)

A. high tones travel faster than low tones.
B. low tones travel faster than high tones.
C. all tones travel at the same velocity.
D. one would have to know the wave-length of each tone to answer the item correctly.
E. it would be necessary to know the distance from the source and the temperature of the air.

79. (1.10) The quality of a musical sound is chiefly dependent on

A. its intensity. **B.** its pitch.
C. the amplitude of the wave. **D.** its overtones.
E. the temperature.

Items 80 - 84. After the number on the answer sheet which corresponds to that of each of the following paired items, blacken space

- **A.** if the item at the left is greater than the item at the right.
- **B.** if the item at the right is greater than the item at the left.
- **C.** if the items are both of equal or no magnitude.

80. (1.10)	Velocity with which the energy associated with electromagnetic waves increases with their wavelength.	....	Extent to which the energy associated with electromagnetic waves increases with their frequency.
81. (1.10)	Extent to which a near-sighted person needs glasses with diverging lenses.	....	Extent to which a near-sighted person needs glasses with converging lenses.
82. (1.10)	Extent to which loudness affects the velocity of sound.	....	Extent to which pitch affects the velocity of sound.
83. (1.10)	Extent to which a ray of light is bent when it enters plate glass at an angle from the air.	....	Extent to which the ray of light is bent as it leaves the plate glass and again travels through the air.
84. (1.10)	Temperature of a star whose spectrum is predominantly red.	....	Temperature of a star whose spectrum is predominantly blue.

Items 85 - 99. After each item number on the answer sheet, blacken space

- **A.** if the item is true of sound.
- **B.** if the item is true of light.
- **C.** if the item is true of both sound and light.
- **D.** if the item is true of neither sound nor light.

85. (1.10) Has a greater velocity in air than in water.

86. (1.10) Has a velocity in a vacuum greater than in any substance.

87. (1.10) Intensity varies inversely as the square of the distance from a point of source.

88. (1.10) Has velocity in air less than that in water.

89. (1.10) Will not travel in a vacuum.

90. (1.10) Requires energy for its production.

91. (1.10) Shows interference effects.

92. (1.10) Has condensations and rarefactions.

93. (1.10) Shows Doppler effect.

94. (1.10) Velocity equals wave length times the frequency.

95. (1.10) Shows transverse wave characteristics.

96. (1.10) Shows longitudinal wave characteristics.

97. (1.10) Subject to diffraction around sharp corners or edges.

98. (1.10) Subject to reflection. **99.** (1.10) Cannot be refracted.

Items 100 - 109. After each item number on the answer sheet, blacken space

- **A.** if the phenomena is primarily caused by or is due to reflection.
- **B.** if the phenomena is primarily caused by or is due to refraction.
- **C.** if the phenomena is primarily caused by or is due to diffraction.
- **D.** if the phenomena is primarily caused by or is due to interference.
- **E.** if the phenomena is primarily caused by or is due to the Doppler effect.

100. (1.10) The colors in a rainbow appearing after a rain.

101. (1.10) Sounds in an empty apartment sound eerie.

Item 102 deleted.

103. (1.10) A divided beam of light converges and gives alternate light and dark bands.

104. (1.10) Photographs of sharp objects seem to give fuzziness at the edges of the objects.

105. (1.10) The determination of the direction of motion of a comet or star.

106. (1.10) Determining the distance of ship to shore with a fog horn.

107. (1.10) One can hear the sounds of the street when in the back yard.

108. (1.10) Sounds on a body of water seem louder during the summer evenings.

109. (1.10) Reverberations in an auditorium are repeated.

Items 110 - 127. The numbers preceding the paired items in the exercise below refer to the corresponding numbers on the answer sheet. Considering each pair from the standpoint of quantity, blacken space

- **A.** if the item in Column I is greater than the item in Column II.
- **B.** if the item in Column II is greater than the item in Column I.
- **C.** if the two items are of essentially the same magnitude.

	Column I		*Column II*
110. (1.10)	Velocity of sound in cold air.	....	Velocity of sound in warm air.
111. (1.10)	Extent to which the medium affects the velocity of sound.	....	Extent to which either loudness or pitch affect the velocity of sound.

	Column I		*Column II*
112. (1.10)	Extent to which the equation $V = f \times 1$ applies to sound waves.	....	Extent to which the equation $V = f \times 1$ applies to light waves.
113. (1.10)	Extent to which a wave in which the particles vibrate at right angles to the direction of propagation resemble light waves.	....	Extent to which a wave in which the particles vibrate at right angles to the direction of propagation resemble sound waves.
114. (1.10)	Extent to which a ray of light is bent when it enters plate glass at an angle from the air.	....	Extent to which the ray of light is bent as it leaves the plate glass and again travels through the air.
115. (1.10)	Velocity of sound in air.	....	Velocity of sound in water.
116. (1.10)	Velocity of light in air.	....	Velocity of light in water.
117. (1.10)	Extent to which the interference phenomena of light support the wave theory of light.	....	Extent to which the interference phenomena of light support the corpuscular theory of light.
118. (1.10)	Amount of light admitted by an f4.5 lens.	....	Amount of light admitted by an f6.3 lens.
119. (1.10)	Extent to which the phenomena of the photoelectric cell support the wave theory of light.	....	Extent to which the phenomena of the photoelectric cell support the corpuscular theory of light.
120. (1.10)	Rate at which light travels through space.	....	Rate at which electromagnetic waves travel through space.
121. (1.10)	Wave-length of X-rays.	....	Wave-length of radio waves.
122. (1.10)	Frequency of ultra-violet light.	....	Frequency of infra-red light.
123. (1.10)	Velocity of waves of ultra-violet light in a vacuum.	....	Velocity of cosmic rays in a vacuum.
124. (1.10)	Extent to which a prism bends violet light.	....	Extent to which a prism bends red light.
125. (1.10)	Temperature of a star whose spectrum is predominantly red.	....	Temperature of a star whose spectrum is predominantly blue.
126. (1.10)	Possibility that an incandescent solid, liquid, or compressed gas will give a bright-line spectrum.	....	Possibility that an incandescent rarefied gas will give a bright-line spectrum.
127. (1.10)	Extent to which a dark-line spectrum indicates the presence of a cooler gaseous envelope surrounding a star.	....	Extent to which a bright-line spectrum indicates the presence of a cooler gaseous envelope surrounding a star.

Items 128 - 141. After each item number on the answer sheet, blacken space

- **A.** if the blank would best be filled by the word "reflection."
- **B.** if the blank would best be filled by the word "refraction."
- **C.** if the blank would best be filled by the word "diffraction."
- **D.** if the blank would best be filled by the word "interference."
- **E.** if the blank would best be filled by the phrase "the Doppler effect."

128. (1.10) Microscopes make use of________in the lenses of their eyepieces and objectives.

129. (1.10) When a ray of light strikes an optically smooth surface, that part of the ray which does not penetrate into the new medium behaves in such a way that the angle of incidence is equal to the angle of________.

130. (1.10) The spectral lines of light from certain distant galaxies are slightly shifted toward the red. This has been interpreted as being due to________.

131. (1.10) When plane water waves pass through a small opening in a breakwater, the waves going through become curved about the opening as a center. This is due to________.

132. (2.10) The spectral lines of the stars in the plane of the earth's orbit show an annual periodic shift in frequency toward the red at one time and toward the violet six months later. This is due to the revolution of the earth about the sun and is an example of________.

133. (1.10) All lenses bend light by________.

134. (1.10) One can see objects which do not themselves emit light only because of________of light.

135. (1.10) A swimming pool ten feet in depth does not appear to be so deep when observed from above, because of ________.

136. (1.10) To raise the pitch of a certain string, a piano tuner

A. loosens the string. **B.** shortens the string.
C. lengthens the string. **D.** tightens the string.
E. puts on a new string.

137. (1.10, If a rope under fixed tension is struck sharply near one end, the motion produced may be described by all these *except*

A. decreasing frequency. **B.** transverse waves.
C. constant velocity. **D.** periodic vibration.
E. decreasing amplitude.

138. (1.10) In a standing wave

- **A.** the wave motion is always transverse.
- **B.** it is necessary to have similar wave trains traveling in opposite directions through the medium.
- **C.** the wave motion is always longitudinal.
- **D.** the distance between positions of no motion is always some even number of half wave lengths.
- **E.** the particles of the medium are everywhere at rest.

139. (1.10) In a wave motion

- **A.** energy is being transferred through some medium.
- **B.** the term "amplitude" applies only to transverse waves.

C. the particles of the medium are always moving away from the center of disturbance.
D. the wave length is the distance a particle of the medium moves.

140. The pitch of the fundamental note of a stretched violin
(1.10) string depends primarily on its

A. length. **B.** diameter.
C. diameter and elastic modulus. **D.** tension.
E. tension, length, and diameter.

141. Of these sound frequencies the one which would make
(1.10) no impression on the average human ear is

A. 256 per sec. **B.** 10,000 per sec.
C. 1000 per sec. **D.** 30,000 per sec.
E. 100 per sec.

142. Resonance may be defined as a condition in which im-
(1.10) pulses supplied to a body

A. cause it to vibrate continuously.
B. periodically interfere with and reinforce its vibrations.
C. are just sufficient to keep it vibrating.
D. reinforce its vibrations because both have the same frequency.

143. The type of wave fundamentally different from the
(1.10) others named is

A. yellow light. **B.** ultra-violet light.
C. infra-red light. **D.** sound. **E.** radio waves.

144. The period of vibration of a stretched cord is nearly
(1.20) *independent* of

A. its length. **B.** its mass per unit length.
C. moderate changes in amplitude of vibration.
D. the tension in the cord. **E.** its diameter.

145. At constant velocity the frequency of a wave is
(1.22a)

A. independent of the wave length.
B. directly proportional to the wave length.
C. inversely proportional to the wave length.
D. related to wave length, but not as in B or C.

146. If the frequency remains the same, as the wave-length
(1.22a) diminishes the velocity

A. increases. **B.** decreases. **C.** remains the same.

147. At constant velocity the frequency of long waves is
(1.22a)

A. less than that of short waves.
B. greater than that of short waves.
C. the same as that of short waves.

148. The velocity of sound is dependent upon all of these
(1.22a) *except*

A. the elasticity of the medium.
B. the amplitude of the wave.
C. the temperature of the medium.
D. the nature of the medium.
E. the density of the material propagating it.

149. If the frequency of a vibrating tuning fork is marked
(1.22a) "256," its *period* is

A. 256 sec. **B.** 2.56 per sec.
C. 256/60 per sec. **D.** 1/256 sec.
E. none of these.

150. A tuning fork vibrating in air gives rise to waves of
(2.10) wave length 'h' feet. If the speed of sound in air is 'v' feet per second, the frequency of the fork in vibrations per second must be

A. $\frac{v}{h}$. **B.** $\frac{v}{h^2}$. **C.** $\frac{2v}{h}$. **D.** $\frac{h}{2v}$. **E.** $\frac{h}{v}$.

151. A wave is sent down a violin string by twanging the
(1.22a) string with one's fingers. Within reasonable limits, the time required for a transverse wave to travel the string is *not* altered by changing the

A. total mass of the string.
B. mass per unit length of the string.
C. amplitude of the wave in the string.
D. length of the string.
E. tension that is stretching the string.

152. In general, the energy carried by a sound wave in-
(1.22a) creases with the

A. wave length. **B.** phase. **C.** harmonic beat.
D. amplitude. **E.** period.

153. Two tones are produced simultaneously, and one is, by
(1.10) design, a harmonic overtone of the other. We can say of this associated wave, that it

A. has the lower frequency.
B. has a higher frequency.
C. has a frequency evenly divisible by the frequency of the other.
D. has a frequency two and one-half times that of the other.
E. is a wave of lesser intensity.

154. A boy some distance up the track from a workman
(1.10) holds his ear near the rail and listens to the workman drive spikes. He notes that he hears the sound of each blow twice and correctly decides it is because

A. his ears are at different distances from the source.
B. part of the wave is reflected between the rails.
C. longitudinal and transverse waves have different speeds.
D. the speed of sound is greater in air than in steel.
E. the speed of sound is greater in steel than in air.

155. The two effects we know as interference and diffraction
(2.30) are common to the mechanics of wave propagation. We can hardly expect them to occur in

A. longitudinal waves. **B.** transverse waves.
C. electromagnetic waves. **D.** all kinds of waves.
E. streams of projectiles.

156. In the case of light transmitted through a single medium,
(1.10) the rays are perpendicular to the wave fronts

A. always. **B.** except in cases of diffraction.
C. except in cases of polarization.
D. except in cases of reflection.
E. except in cases of refraction.

157. The pitch of a sound varies
(1.22a)

A. inversely as the frequency.
B. directly as the number of overtones.
C. inversely as the wave length.
D. as the square of the amplitude.
E. directly as the loudness.

158. The pitch of a sound is directly proportional to
(1.22a)

A. amplitude. **B.** frequency. **C.** period.
D. phase. **E.** wave length.

159. The speed of sound waves in air increases as
(1.22a)

A. the pressure rises. **B.** the pressure falls.
C. the temperature rises. **D.** the temperature falls.
E. the distance increases.

160. The type of wave fundamentally different from the others named is
(1.23)

A. yellow light. **B.** ultra-violet light.
C. infra-red light. **D.** sound. **E.** radio waves.

161. Which of the following factors has the greatest effect on the velocity of sound in air?
(1.10)

A. The temperature of the air.
B. Changes in atmospheric pressure near the earth's surface.
C. The loudness of the sound.
D. The energy associated with the sound wave.
E. The pitch or frequency of the sound.

162. A tuning fork vibrating over a cylinder partially filled with water is a means of determining the velocity of sound in air. This method of determining the velocity of sound involves an application of the
(1.30)

A. Doppler principle.
B. principle of interference and reinforcement of sound waves.
C. principle that sound travels more rapidly in liquids than in air.
D. principle that the frequency of vibration of a tuning fork is proportional to the velocity of sound.

163. In a sound wave in air
(1.30)

A. the air disturbed at the source itself moves outward to the ultimate receiver.
B. the alternate compressions and rarefactions move away from the source.
C. any tiny volume of air moves as fast as the wave moves.
D. any tiny volume of air moves at least the length of one wave.
E. the wave causes an appreciable wind.

164. When a wave front meets a reflecting surface, the direction taken by the reflected wave is determined by the
(1.30)

A. material of the reflecting surface.
B. angle of incidence. **C.** nature of the medium.
D. intensity of the disturbance.
E. wave length of the light.

165. The essence of wave motion is
(2.10)

A. the movement of matter in a horizontal direction.
B. the movement of matter in a vertical direction.
C. circular movement of matter.
D. transfer of matter. **E.** transfer of energy.
F. none of these.

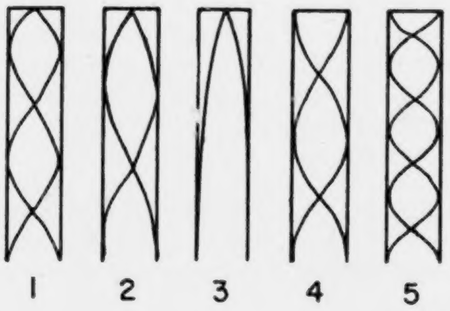
166. A wave has a frequency of 20 and a wave length of 3 ft. The velocity is
(2.10)

A. 60 ft/sec. **B.** 6.67 ft/sec. **C.** 0.15 ft/sec.
D. 20 ft/sec. **E.** none of these.

167. Water waves in the sea have a wave length of 1,000 ft. and a frequency of 0.07 waves per second. The velocity of the wave is
(2.10)

A. 0.0007 feet per second. **B.** 7 feet per second.
C. 70 feet per second. **D.** 700 feet per second.
E. none of these.

Items 168 - 171 refer to the organ pipes in the following diagram. For each item select the number of the pipe which fulfills the condition indicated.



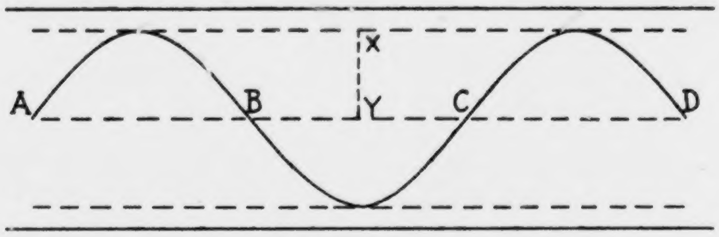
168. A pipe showing exactly one whole standing wave.
(2.10)

169. A pipe giving its fundamental tone.
(2.10)

170. The pipe emitting the tone of highest pitch.
(2.10)

171. The pipe giving the second resonance point beyond the fundamental.
(2.10)

Items 172 - 175 refer to the diagram below. For each item select the most appropriate response.



KEY

A. Amplitude. **B.** Frequency. **C.** Wave length.
D. Period. **E.** None of these.

172. The time for the disturbance at A to be transmitted to C.
(2.10)

173. The distance C to D.
(2.10)

174. The product of the number of vibrations per second and the distance B to D.
(2.10)

175. The distance x to y.
(2.10)

176. The quantity obtained by dividing the velocity of a wave by its frequency is a measure of
(2.10)

A. amplitude. **B.** frequency. **C.** decibel value.
D. acoustical ratio. **E.** wave length.

177. A sound travels 1100 feet per second. It is made by a source vibrating 500 times per second. The wave length of the sound in feet is
(2.10)

A. 2.20. **B.** 5.00. **C.** 5.5×10^5. **D.** 22.0.
E. 2.2×10^{-5}.

178. (2.10) If two adjacent pianos are so tuned that middle C on one varies 2 vibrations per second from middle C on the other and if middle C is struck on both simultaneously there will result a phenomena known as

A. incomplete dominance. **B.** the standing wave.
C. sympathetic vibration. **D.** beats.
E. the Doppler-Fizeau principle.

179. (2.10) Simple harmonic motion is best illustrated by

A. the motion of a particle in a transverse wave.
B. a revolving door in a store entrance.
C. whirling a stone on the end of a string.
D. the acceleration produced by the force of gravity on a falling body.
E. none of these.

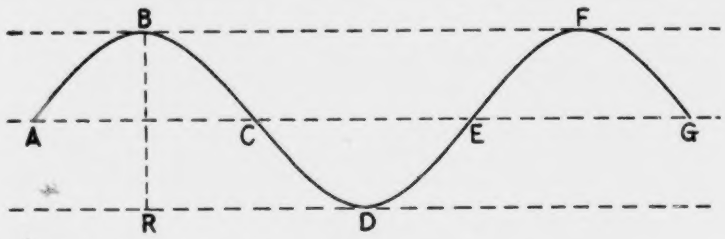
180. (2.10) If the air in a closed organ pipe is in resonance with a tuning fork, so that the air column contains two nodes and two antinodes, the length of the pipe is approximately

A. ¼ of a wave length. **B.** ½ of a wave length.
C. ¾ of a wave length. **D.** 1 wave length.
E. 2 wave lengths.

181. (2.10) When a string is vibrated continuously so that three nodes and two antinodes are visible in its length, the number of wave lengths present in the string is

A. one. **B.** two. **C.** three. **D.** four.
E. some fractional part of a wave length.

Items 182 - 188 refer to an approximate sine curve traveling from left to right which is characteristic of many wave motions. For each item select from the key the most appropriate response.



KEY

A. Amplitude. **B.** Frequency. **C.** Period.
D. Wave length. **E.** None of these.

182. (2.10) The distance from C to D.

183. (2.10) The time for a complete wave to pass point C.

184. (2.10) The number of waves per unit of time passing point E.

185. (2.10) The distance B to R.

186. (2.10) The distance from B to F.

187. (2.10) The time required for a wave to travel from A to E.

188. (2.10) The distance C to G.

189. (2.10) Pitch in sound corresponds in light to

A. color. **B.** Doppler effect. **C.** brightness.
D. interference fringes. **E.** velocity.

190. (2.10) A musical chord could be considered as corresponding in light to

A. the Doppler effect. **B.** brightness.
C. mixtures of wave lengths. **D.** monochromatic light.
E. amplitude.

191. (1.10) When frequency of one tone is twice the frequency of another they are said to

A. be an octave apart. **B.** be dissonant.
C. have the same pitch.
D. always be of equal loudness.
E. have the same timbre.

192. (1.10) One can distinguish whether "C" (256 vibrations) is sounded on a piano or on a saxophone because they differ in

A. wave length. **B.** amplitude. **C.** overtones.
D. fundamentals. **E.** velocity.

193. (1.10) Sound travels fastest in

A. air. **B.** steel. **C.** water. **D.** steam.
E. a vacuum.

194. (2.10) Loudness in sound corresponds in light to

A. color. **B.** Doppler effect. **C.** brightness.
D. frequency.

195. (2.10) A piano tuner hears four beats per second when he sounds a fork with a frequency of 256, and at the same time strikes the C string on the piano. After he tightens the piano string, he hears six beats per second. The frequency of the piano string at first must have been

A. 262. **B.** 252. **C.** 250. **D.** 260. **E.** 266.

196. (2.10) If a sound wave has a velocity of 1100 ft./sec., a wave length of 4.4 ft. and a frequency of 250 vibrations per sec., the period is

A. .004 sec. **B.** 4.4 sec. **C.** 1.0 sec.
D. 250 sec. **E.** none of these.

197. (2.10) The frequency (n) of a vibrating string varies directly with the square root of the applied force (F), indirectly with the square root of the mass per unit length (m_1), and inversely with the length (L) of the string. The variation expressed by these quantities may be expressed by

A. $n \alpha \frac{F^2}{Lm_1{}^2}$. **B.** $n \alpha \frac{F}{m_1}\sqrt{\frac{1}{L}}$. **C.** $n \alpha \frac{1}{L}\sqrt{\frac{m_1}{F}}$.
D. $n \alpha \frac{1}{L}\sqrt{\frac{F}{m_1}}$. **E.** none of these.

198. (2.10) If an open organ pipe 200 cm. long is in resonance with a sound of wave length 200 cm., the pipe must be responding with its

A. 1st position of resonance or fundamental.
B. 2nd position of resonance or 1st overtone.
C. 3rd position of resonance or 2nd overtone.
D. 4th position of resonance or 3rd overtone.

199. (2.10) If the velocity of a wave motion in a certain medium is V, and the frequency is 360, the length of the waves in the medium is

A. V/360. **B.** 360/V. **C.** 360V. **D.** $360V^2$. **E.** 360 — V.

Items 200 and 201. It is found that the crest moves from b to f in 2 seconds. (See diagram below.)

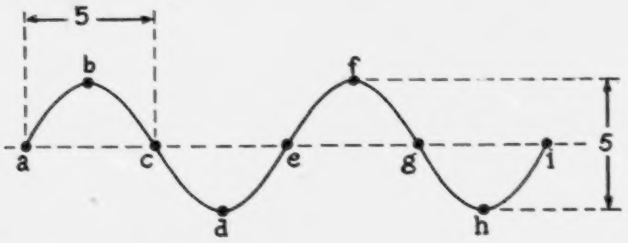
200. (2.10) The frequency of the wave motion is

A. 2 per sec. **B.** ½ per sec. **C.** 4 per sec. **D.** ¼ per sec. **E.** 2.5 per sec.

201. (2.10) The velocity of the wave motion is

A. 10 cms./sec. **B.** 20 cms./sec. **C.** 5 cms./sec. **D.** 2.5 cms./sec. **E.** 2 cms./sec.

Items 202 - 204 refer to the following diagram. The diagram represents a train of waves. The horizontal distance ac is 5 cms. and the vertical distance between the levels bf and dh is 5 cms.



202. (2.10) The wave length is

A. ab. **B.** ac. **C.** bd. **D.** cg. **E.** ag.

203. (2.10) Two points which are in opposite phase (180° difference) are

A. a and e. **B.** b and d. **C.** c and g. **D.** a and d. **E.** d and i.

204. (2.10) The amplitude of the wave motion is

A. 5 cms. **B.** 2.5 cms. **C.** 10 cms. **D.** unknown from the data given.

205. (2.10) If I hear 4 beats a second when two tuning forks are sounding, and the frequency of the higher fork is 256, I know the frequency of the other is

A. 64. **B.** 252 **C.** 260. **D.** 512. **E.** 1024.

206. (2.10) Standing waves are caused by the

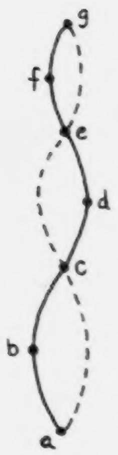
A. interference of two similar wave trains going in opposite directions.
B. superposition of two wave trains of different wave length.
C. momentary pause of the particles of the medium at the end of a complete vibration.
D. nodes of one wave alternating with the loops of another.

207. (2.10) Of two sound wave trains, the one of greater frequency gives rise to the note of

A. lesser intensity. **B.** higher pitch. **C.** lower pitch. **D.** greater loudness. **E.** better quality.

208. (2.10) The wave length of a 1000 kilocycle radio broadcast radiation is

A. 30,000,000 meters. **B.** 30,000 meters. **C.** 300 meters. **D.** 30 meters. **E.** 3 meters.



Items 209 - 217. The diagram represents a standing wave in a spring. From the appropriate key, select the correct completion for each statement and mark corresponding answer space.

Items 209 - 211.

KEY

A. A change in the wave length of the wave motion.
B. A lessened amplitude of the wave motion.
C. Interference and reinforcement. **D.** Interference.
E. Reinforcement.

209. (2.10) The phenomenon is due to________caused by the reflection of the wave at the top.

210. (2.10) At points a, c, e, and g there is________.

211. (2.10) At points b, d, and f there is________.

Items 212 - 217.

KEY

A. A node. **B.** An antinode. **C.** A crest.
D. A trough. **E.** A minimum or maximum.

212. (2.10) The point a, c, e, or g is called________.

213. (2.10) The point b, d, or f is called________.

214. (2.10) A node is caused by the simultaneous arrival of a crest and________.

or

215. (2.10) A trough and________.

216. (2.10) An antinode is caused by the simultaneous arrival of a crest and________.

or

217. (2.10) A trough and________.

218. (2.30) If we steadily decrease the frequency of a sound wave we reach the point where

A. the sound is too low in intensity to be heard.
B. the sound has too low a pitch to be heard.
C. the amplitude of the wave is zero.
D. the wave form becomes complex.
E. the sound has too high a pitch to be heard.

219. Certain interrelationships regarding the characteristics
(3.00) of vibrating strings may be expressed by the equation:

$$N = \frac{1}{L}\sqrt{\frac{F}{M}}$$

N = frequency
F = force
m = mass per unit length
L = length

It is desired that two different lengths of the same string produce tones of equal frequency. If one string were twice the length of the other it would have to be kept under a tension

A. twice as great. **B.** ¼ as great.
C. 4 times as great. **D.** ½ as great. **E.** none of these.

220. If the wave length of a sound wave from a closed
(3.00) organ pipe giving its fundamental tone is 130 cms., the length of the pipe is

A. 32.5 cms. **B.** 65.0 cms. **C.** 130 cms.
D. 260 cms. **E.** 107.5 cms.

Items 221 and 222 refer to the fact that telephone wires are often observed to hum.

221. The pitch of the sound on a cold day, in comparison
(3.00) to a warm day, will be

A. lower. **B.** higher. **C.** the same.

222. Because
(3.00)

A. the distance between the poles remains the same.
B. an increase in the tension of the wire reduces the frequency of vibration.
C. higher winds on colder days make the wire vibrate more rapidly.
D. a reduction in temperature makes the wire contract and thus be under a greater tension.
E. in the same way that the velocity of sound increases with increase in temperature, the rate of vibration of the wire increases as the temperature is reduced.

Items 223 and 224 refer to sound as heard in a movie theater.

223. Sound is more apt to be distinct and pleasing when
(3.00)

A. the walls are hard plaster.
B. the theater is nearly empty.
C. the theater is full of people.
D. the theater is dark.

224. Because
(3.00)

A. smooth walls are better reflectors of sound.
B. sound is more distinct when a minimum of reflection occurs.
C. sound is more easily heard in the dark when people are quiet.
D. with just a few people present, there is more opportunity to receive the sound waves.
E. with just a few people present, there is a better chance to absorb the sound energy.

Items 225 - 227. The shadow of an object vibrating with Simple Harmonic Motion is thrown on a screen by a beam of parallel light. The length of the shadow's path from one end to the other is 10 cms. and the time to cover this distance is 2 seconds.

225. The frequency of the S.H.M. is
(3.00)

A. 4 per sec. **B.** 2 per sec. **C.** ½ per sec.
D. ¼ per sec. **E.** 10 per sec.

226. The velocity at the center of the path is
(3.00)

A. 2.5π cms./sec. **B.** 5 cms./sec.
C. 20π cms./sec. **D.** 10 cms./sec.
E. 5π cms./sec.

227. The acceleration at the end of the path is
(3.00)

A. π^2 cms./sec./sec. **B.** 215 cms./sec./sec.
C. $5\pi^2/4$ cms./sec./sec. **D.** 10π cms./sec./sec.
E. 342 cms./sec./sec.

228. One open organ pipe, A, is twice the length of a second,
(3.00) B. The fundamental note of A is

A. the same as that of B. **B.** one-fourth that of B.
C. one-half that of B. **D.** twice that of B.
E. four times that of B.

Items 229 - 231. The velocity of sound in air is 340 meters/sec. An observer is moving toward a sound source of frequency 340 cycles/sec. with a velocity of 20 meters/sec.

229. The number of waves picked up per sec. due to the
(3.00) observer's motion is

A. 1. **B.** 20. **C.** 40. **D.** 60. **E.** 80.

230. The frequency of the sound as heard by the observer is
(3.00)

A. 300. **B.** 310. **C.** 320. **D.** 340. **E.** 360.

231. If the observer is moving away from the sound source
(3.00) with a velocity of 20 meters/sec. the observed frequency is

A. 300. **B.** 310. **C.** 320. **D.** 340. **E.** 360.

232. While a tuning fork whose frequency is 100 vibrations
(3.00) per second is making one complete vibration, the sound wave it produces in air advances (speed of sound in air is 1100 feet per second)

A. about 11 feet. **B.** about 100 feet.
C. about 1100 feet.
D. a distance equal to two wave lengths of sound in air.
E. 110,000 feet.

For items 233 - 239, blacken space

A. if the statement is true and is supported by the reason given.
B. if the statement is true, but the reason given is false.
C. if the statement is false.

233. The velocity of a sound of high frequency is necessarily
(4.20) greater than that of low frequency, because $V = f l$.

234. There may be reverberations in an auditorium, because
(4.20) the room has too much sound-absorbing material in it.

235. All sounds must originate from vibrating bodies, because
(4.20) sound is a wave motion.

236. For a given wave velocity, the longer the wave length,
(4.20) the lower the frequency is, because $V = f l$.

237. Sounds travel faster in cold air than in warm air, be-
(4.20) cause cold air is more dense.

238. Sounds of different pitch travel at the same velocity,
(4.20) because musical notes played simultaneously reach distant hearers at the same time.

239. Sounds travel faster in gases than in liquids or solids,
(4.20) because gases are less dense.

240. (4.20) In the statement: If either the source of waves or the position of the observer changes with respect to each other, there is a change *in the* frequency because of interference,

A. the first part of the statement is true, and its truth is supported by the reason given in the statement.
B. the first part is true, but its truth is *not* supported by the reason given.
C. the first part of the statement is false.

241. (4.20) An organ pipe emitting a C note and a violin emitting a D note at the same time, will be alike in that

A. both produce transverse waves.
B. the tones have equal wave lengths.
C. the quality of tone is the same.
D. the sound waves have equal frequencies.
E. standing waves are produced.

242. (4.20) Consider a water wave, a vibrating spring, a wave in a rope, a sound wave, and light. The only way in which they differ is

A. some represent a transfer of energy, others do not.
B. some require energy to initiate them, others do not.
C. some require a material medium for their transmission, others do not.
D. some are reflected, refracted and diffracted, others are not.
E. some show reinforcement, others show interference.

22. *Physical and Chemical Changes*

PHYSICAL AND CHEMICAL CHANGES

1. (1.10) The fractional distillation of liquid air is used commercially to obtain

A. dry ice. **B.** ammonia. **C.** oxygen.
D. carbon dioxide. **E.** hydrogen.

2. (1.10) Which one of the following is true concerning the heating of various substances in laboratory experiments?

A. Iron and sulfur combined on heating.
B. Halite remained unchanged on heating.
C. Steel wool decreased in weight on heating.
D. Sodium bicarbonate gained weight on heating.
E. Heat always produces a chemical change.

Items 3 - 6. Many chemical and physical changes are involved in daily activities. For the following items select from the key the type of change most closely related to the statement.

KEY

A. Ionization. **B.** Neutralization.
C. Oxidation-reduction. **D.** Physical change.
E. None of these.

3. (1.10) Soil is often *sweetened* with lime.

4. (1.10) Many families *burn* gas.

5. (1.10) The *fission* of uranium led to the development of the atomic bomb.

6. (1.10) During thunderstorms *flashes of lightning* occur.

7. (1.10) Which one of the following is the best example of a chemical change?

A. Defrosting a refrigerator.
B. Filtering drinking water. **C.** Liquefying air.
D. Adding anti-freeze to a car radiator.
E. Passing an electric current through a solution.

8. (1.10) The combining of a substance with a definite amount of water during crystallization is called

A. sublimation. **B.** saturation. **C.** evaporation.
D. hydration. **E.** ionization.

9. (1.10) A chemical change is always produced in

A. changes of state of matter.
B. crystallization of salts from saturated solutions.
C. osmosis through a semi-permeable membrane.
D. solution of a solute in a liquid.
E. passing an electric current through an electrolyte.

10. (1.10) The process of vaporizing a liquid and condensing the vapor is known as

A. precipitation. **B.** distillation. **C.** sublimation.
D. extrapolation. **E.** interpolation.

11. (1.10) Charcoal is made by a process known as

A. carbonation. **B.** organic synthesis.
C. destructive distillation. **D.** hydration.
E. oxidation.

12. (1.10) When a solid is changed to a gas or back again without melting, the process is called

A. osmosis. **B.** electrolysis. **C.** sublimation.
D. boiling. **E.** dissociation.

13. (1.10) Chemically pure water may be made by

A. electrolysis. **B.** distillation. **C.** filtering.
D. boiling. **E.** catalysis.

14. (1.10) Chlorine

A. unites with hydrogen to form the hydrogen halide of greatest stability.
B. can be made by electrolysis of its compounds with the nonmetallic elements.
C. unites with hydrogen by a chain reaction.
D. loses electrons more easily than bromine.
E. is often produced commercially by the electrolysis of molten potassium chloride.

15. (1.10) A chemical change is one in which

A. the substances alter their state (gas, liquid, solid).
B. heat is always given off.
C. new substances are formed the total energy of which is the same as the total energy of the reactants.
D. the identities of the substances are changed.
E. new substances are formed the total weight of which is always slightly less than the total weight of the reactants.

16. (1.10) When sulfur is heated

(1.25) **A.** the monoclinic variety changes to the rhombic.
B. at the melting point, the liquid is dark brown in color and very viscous.
C. monoclinic crystals are formed by allowing liquid sulfur, not heated much above its melting point, to freeze.
D. various isotopes of sulfur are formed as the temperature rises.
E. plastic sulfur is a mixture of the monoclinic and rhombic varieties.

17. (1.10) The hardness of water *cannot* be removed by which of the following?

A. boiling.
B. addition of Na_2CO_3 to precipitate $CaCO_3$.
C. distillation. **D.** addition of $MgCl_2$.
E. use of ion-exchange minerals or resins.

18. (1.25) Sulfur dioxide

A. is a stable compound whose density is almost equal to that of oxygen.
B. is obtained by the combustion of iron pyrites.
C. yields a monoprotic acid when it dissolves in water.
D. is only liquefied with great difficulty.
E. contains sulfur with an oxidation state of +2.

Item 19 deleted.

20. (1.30) $CuSO_4 \cdot 5H_2O$ is considered a chemical compound because

A. it gives off water when heated.
B. when it is powdered it loses its characteristic blue color.

C. the water in the compound evaporates readily.
D. it always contains 5 molecules of water per molecule of $CuSO_4$.
E. it becomes opaque when heated.

21. For which one of the following reasons may *we consider*
(1.30) the dissolving of salt in water to be a physical change?

A. The salt becomes invisible.
B. The water combines with the salt.
C. The residue from evaporation of the solution is unaltered.
D. The residue from evaporation of the solution is not salt.
E. None of the above; this is actually a chemical change, and the above are not applicable.

22. Which of the following alterations of a substance would
(1.30) indicate that this substance had undergone a chemical rather than a physical change?

A. Change in density. **B.** Change in odor or taste.
C. Change in volume. **D.** Change in viscosity.
E. All of these indicate that the change was chemical.

For items 23 - 25 identify the following according to the key.

KEY

A. A physical change. **B.** A chemical change.
C. Insufficient information to classify as either physical or chemical.

23. A red liquid disappears as an invisible gas.
(2.10)

24. A mass of crystals forms in a container of fruit juice
(2.10) after it was sealed for several months.

25. The specific gravity of a liquid changes gradually from
(2.10) 1.2 to 1.1 while being warmed.

26. Which one of these represents a physical change rather
(2.10) than a chemical one?

A. Bleaching clothes. **B.** Destructive distillation.
C. Roasting meat. **D.** Synthesis of nitrates.
E. None of the above.

27. Which one of the following is the best example of a
(2.10) chemical change?

A. The disappearance of dry ice.
B. Adding alcohol to water.
C. Evaporating salt water.
D. Chlorination of drinking water.
E. Distilling water.

28. Consider the following changes: (A) the grinding of
(2.10) wheat to flour; (B) the drying of clothes; (C) the drying of paint; (D) the making of "burnt" toast; (E) the melting of ice. How many of these are strictly physical changes?

A. 1. **B.** 2. **C.** 3. **D.** 4. **E.** 5.

29. A certain material on extraction with water left a solid
(2.40) residue. The water extract on evaporation also formed a solid residue. These facts definitely show that the original material was

A. an electrolyte. **B.** an element. **C.** a compound.
D. a mixture. **E.** a salt.

Items 30 - 32 refer to the following. A mixture of iron and sulfur was heated until the reaction ceased. When the product was tested with a magnet it was found to be magnetic. A sample of pure iron sulfide was tested with the magnet and found to be non-magnetic.

30. Which of the following assumptions would explain the
(4.20) magnetic properties of the product?

A. An excess of sulfur is present in the product.
B. There was not enough sulfur in the reactants.
C. There was not enough iron in the reactants.
D. The relative amounts of iron and sulfur are not important.

31. The product obtained in the reaction was a
(1.10)

A. compound. **B.** mixture. **C.** physical change.
D. chemical change. **E.** change of state.

32. The formation of the iron sulfide is an example of a
(1.10)

A. compound. **B.** mixture. **C.** physical change.
D. chemical change. **E.** change of state.

23. *Colloidal State; Solutions and Mixtures*

COLLOIDAL STATE;
SOLUTIONS AND MIXTURES

1. (1.10) Air can be classed as a (an)

A. solution. **B.** mixture of dissociated gases.
C. element. **D.** electrolyte. **E.** compound.

2. (1.10) Which of the following statements is true?

- **A.** The solubility in water of most compounds usually increases with a rise in temperature, the amount of the increase varying greatly with the compound.
- **B.** The solubilities of compounds in liquids, such as benzene or alcohol, are proportional to their solubilities in water.
- **C.** The composition of the solute and that of the solvent are the only factors that determine solubility.
- **D.** The solubility of any compound in water is directly proportional to the temperature of the solution.
- **E.** Water solutions of compounds boil at 100°C.

3. (1.10) Adding a solute to a solvent will

- **A.** raise the freezing point but not affect the boiling point.
- **B.** raise the boiling point but not affect the freezing point.
- **C.** raise the freezing point and the boiling point.
- **D.** lower the freezing point and raise the boiling point.
- **E.** lower the freezing point and the boiling point.

4. (1.10) All of the following concerning a solution are true *except* that

- **A.** the homogeneous condition is permanent.
- **B.** a solid solution may exist.
- **C.** a liquid solution is clear but may have color.
- **D.** heavy solute particles may settle out.
- **E.** air may be classed as a solution.

5. (1.10) A gas is most soluble in water at

- **A.** low pressure and low temperature.
- **B.** high pressure and high temperature.
- **C.** high pressure and low temperature.
- **D.** low pressure and high temperature.
- **E.** pressure and temperature have no effect on the solubility of a gas in water.

6. (1.10) The cleaning properties of a soap solution are to the greatest extent due to

A. reduced surface tension. **B.** increased solubility.
C. increased cohesive forces.
D. increased molecular motion.
E. reduced chemical activity.

For items 7 - 11 select from the key the most appropriate response.

KEY

A. Element. **B.** Compound. **C.** Mixture.
D. Solution. **E.** Two of the above.

7. (1.10) Granite. **8.** (1.10) A noble metal. **9.** (1.10) Air.

10. (1.10) Silica. **11.** (1.10) Graphite.

12. (1.10) Milk may be considered as a colloidal suspension of fats and proteins in water. The fats and proteins may be precipitated from the suspension by

A. adding an acid. **B.** allowing the milk to settle.
C. pasteurization. **D.** homogenization.
E. filtration.

13. (1.10) All alloys can be termed

A. isotopes. **B.** elements. **C.** mixtures.
D. compounds. **E.** polymers.

14. (1.10) Which of the following is not a general property of solutions?

- **A.** The molecules of the solute are separated from each other as they become distributed throughout the solvent.
- **B.** They are always clear but not necessarily colorless.
- **C.** They are homogeneous after thorough stirring.
- **D.** The homogeneous condition is permanent.
- **E.** Water is always the solvent.

15. (1.10) Dialysis is the

- **A.** separation of ions from colloidal suspensions.
- **B.** coagulation of colloids by ions.
- **C.** movement of colloidal particles in an electrical field.
- **D.** effect of water on a lyophilic colloid.
- **E.** migration of solvent from dilute to strong solutions.

16. (1.10) The ultramicroscope

- **A.** is the same as the electron microscope.
- **B.** is an extremely powerful microscope.
- **C.** produces colloids by the method of dispersion.
- **D.** is a necessary part of the Cottrell process.
- **E.** views the Tyndall cone at a right angle to the source of light.

17 (1.10) Lyophilic colloids

A. coagulate to form gels. **B.** are extremely unstable.
C. are usually made by the Bredig process.
D. are only made from inorganic materials.
E. are usually made in a colloid mill.

18. (1.10) Silver

- **A.** oxidizes readily at room temperature in the air.
- **B.** is like sodium in that it forms a soluble chloride.
- **C.** in the action $Ag \rightleftarrows Ag^+ + e$ has an E° value that is positive.
- **D.** is not acted upon by any acid.
- **E.** dissolves in aqueous solutions containing the CN^- ion.

19. (1.24) Which one of the following would yield the most reliable evidence in determining or distinguishing whether a substance had merely gone into solution, or had actually undergone a chemical change?

A. A change in mass. **B.** A change in viscosity.
C. A change in miscibility.
D. Whether or not the substances would separate upon boiling.
E. None of the above.

20. (1.24) Which of the following statements would tell you most about whether a given portion of matter is a pure substance or a mixture?

A. It all dissolves in the same solvent.
B. Solutions of different concentrations are found to possess different properties.
C. When heated unevenly, the portion which is hottest melts first.
D. The matter is observed, under a microscope, to be composed of particles of different sizes.
E. The large particles are found to be of greater density than the small particles.

21. (1.25) A chalk and salt mixture could be separated into its component substances by

A. adding water and shaking.
B. adding water, boiling, and filtering.
C. adding water, and distilling.
D. adding water, boiling, and cooling.
E. subliming the salt out of the mixture.

22. (1.25) Nitrogen and oxygen, the principle constituents of the air, are present in a practically constant ratio of 3.2 grams of nitrogen to every one gram of oxygen. The two elements can also be made to combine chemically, forming the compound nitric oxide, which contains seven grams of nitrogen to every eight grams of oxygen. Both air and nitric oxide are colorless gases. An experimental method for showing that one is a compound and the other is a mixture, would be to

A. compress and cool a sample of each gas until liquefaction took place.
B. examine a sample of each gas under the microscope.
C. weigh equal volumes of each gas.
D. add a sample of one gas to a sample of the other, and let them stand overnight.
E. let them both stand undisturbed for a long period of time, and then to carefully remove samples from both the top and bottom of the containers for examination.

23. (1.25) The freezing point depression method of molecular weight determination is particularly useful because

A. it is much more accurate than the vapor density method.
B. many more substances can be examined in solution than as vapors.
C. vapor densities require a knowledge of Avogadro's number.
D. it is easier to measure a temperature than to determine a weight.
E. substances of high molecular weights produce such large depressions.

24. (1.25) Colloidal suspensions may be produced

A. sometimes by mixing solutions which might be expected to give a visible precipitate.
B. by the Tyndall effect.
C. by adding an emulsifying agent to water.
D. by passing an electric current through carefully purified water.
E. by mixing electrolyte solutions that can form no insoluble substances by reaction.

25. (1.25) The Cottrell process is

A. a method of preparing colloids.
B. a method of imparting a charge to particles, suspended in the air, so that they are driven to a plate of opposite charge.
C. a method of dialysis.
D. a method of increasing the humidity of the air.
E. an interesting theoretical method of precipitating colloids, but one that has no practical application.

26. (1.25) In the method of Bredig

A. a current passes through a wire held under water.
B. no trace of an electrolyte should be present in the liquid.
C. smokes are precipitated.
D. metals are changed to gases by an arc under water, and the gas condenses to colloidal particles.
E. a colloid mill is used.

27. (1.31) Cerous sulfate is more soluble in cold water than in hot water. Therefore, when this compound is dissolved in water, it is likely that heat will be

A. absorbed from the surroundings.
B. given up to the surroundings.
C. neither absorbed nor given up since there is ordinarily no connection between heat effect and solubility.

28. (1.31) The presence of sugar at the bottom of a cup of cold coffee *cannot* be explained by the fact that

A. more sugar was put into the coffee than could be dissolved.
B. sugar was deposited as the coffee cooled.
C. the coffee was not stirred sufficiently.
D. some sugar precipitated when cream was added.
E. the coffee was supersaturated.

29. (1.30) It is difficult to cook potatoes in water at the top of a high mountain because water boils there at a relatively low temperature. This difficulty might be overcome by

A. using a larger flame so as to boil the water more rapidly.
B. using distilled water.
C. using an aluminum kettle so as to distribute the heat more evenly.
D. using a larger kettle. **E.** putting salt in the water.

30. (1.30) According to Raoult's law

A. a crystal deliquesces if its vapor pressure is less than that of pure water.
B. the freezing points of all aqueous solutions of the same percentage concentration are identical.
C. a molal solution of a very soluble substance in a given solvent always boils at a higher temperature than a molal solution of a substance less soluble in that solvent.
D. the vapor pressure of a solution is directly proportional to its molecular concentration.
E. in a solution the lowering of vapor pressure of the solvent is proportional to the mole fraction of the solute.

31. Which of the following is *not* true?
(1.30)

A. The ability of water to dissolve substances depends upon the attractive forces between water molecules and the substance.
B. The maximum quantity of substance that can be dissolved in a certain amount of water is its solubility.
C. It is possible to have a solution containing more of a substance than would be allowed on the basis of this solubility alone.
D. A saturated solution is one containing an amount of solute per unit amount of solvent which is equal to its solubility.
E. If we have solid NaCl in contact with a saturated solution of NaCl in water no more NaCl molecules, Na ions or Cl ions dissolve.

32. Which of the following statements *is not* true?
(1.30)

A. Gases usually are not very soluble in liquids although there are many exceptions.
B. Gas solubility in liquids usually increases with an increase in pressure.
C. Gas solubility in liquids usually increases with an increase in temperature.
D. Gases mix with other gases always.
E. Some solid elements can be combined after melting and freezing to form solutions of solid in solid.

33. Which of the following statements is *not* true?
(1.30)

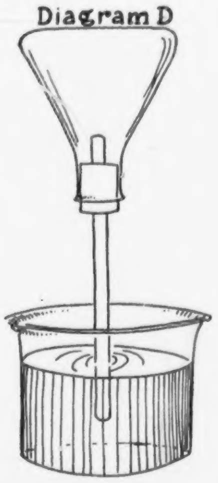
A. Water is a polar compound.
B. Water molecules may form hydrogen bonds with other water molecules.
C. Water will conduct electricity to a small extent.
D. Water ionizes to form hydronium ions and hydroxide ions.
E. Water combines with other compounds to form hydrates by a process called hydrolysis.

34. A substance may be considered to be homogeneous when
(2.10)

A. every particle is like every other particle.
B. it is composed of particles whose properties may be quite different.
C. its density is 1 g/cc.
D. it is composed of two different elements.
E. its density approaches that of water.

For item 35 refer to diagram D.

Diagram D



A flask was filled with hydrogen chloride vapor and connected to a tube which dipped into a beaker of water as shown in the diagram. As a result, water entered the flask and continued like a fountain for some time.

35. The action continues rapidly because
(2.20)

A. HCl vapor dissolves in water.
B. water is siphoned from the beaker to the flask.
C. HCl vapor diffuses through the tube into the water and pushes the water upward.
D. as water enters the flask it evaporates and increases the pressure in the flask.
E. as water enters it compresses the HCl vapor.

36. A chemical reaction between two solid substances usually proceeds quite slowly. However, many of these reactions proceed rapidly in a water solution. This is due to the fact that
(2.20)

A. all solutes when dissolved become catalysts.
B. a decrease in particle size increases surface area.
C. undissociated water molecules are formed.
D. equilibrium is quickly attained.
E. all solutes ionize when dissolved.

37. In the action $AB \rightleftarrows A + B + 80{,}000$ cal.
(3.00)

A. the value of the equilibrium constant K changes with changes of temperature.
B. increase in the concentration of B changes the value of K.
C. the escape of B as a gas decreases the concentration of A, if AB and A are in solution.
D. increase of temperature shifts the equilibrium point to the right, if all the substances are gases.
E. positive catalysts shift the equilibrium point.

38. The atomic weight of sulfur is 32 and of oxygen is 16. If 1 gram of sulfuric acid (H_2SO_4) is dissolved in enough water to make 1 liter of solution, the resulting concentration will be about what value?
(3.00)

39. The atomic weight of Na is 23, of C is 12, and of O is 16. If 10.6 grams of Na_2CO_3 are dissolved in 50 ml of water, the molality of the solution will be
(3.00)

A. 0.1 molal. **B.** 0.1 molar. **C.** 2 molal.
D. 2 molar. **E.** 1 molal.

40. If 10.6 grams of Na_2CO_3 (see item 39) is dissolved in enough water to make 200 cc of solution, the resulting concentration will be
(3.00)

A. 0.1 molal. **B.** 0.1 molar. **C.** 0.5 molal.
D. 0.5 molar. **E.** 1 molal.

41. If 300 ml of a 10 molar solution of HCl in water is diluted to 700 ml, the resulting concentration will be
(3.00)

A. 2.1 molar. **B.** 4.3 molar. **C.** 2.3 molar.
D. 3.0 molar **E.** 7.0 molar.

42. How many ml of 6 N sulfuric acid would be required to make 1 liter of 2.5 N solution?
(3.00)

A. 417 ml. **B.** 240 ml. **C.** 150 ml. **D.** 218 ml.
E. None of the above.

43. (3.00) The atomic weight of Na is 23 and of Cl is 35. What is the concentration of NaCl in terms of weight percent in a 10 molal solution of NaCl in water?

A. 58.0 weight percent NaCl.
B. 27.3 weight percent NaCl.
C. 63.3 weight percent NaCl.
D. 36.7 weight percent NaCl.
E. Cannot calculate unless the density is known.

44. (3.00) If you add one mole of sugar (non-ionic) to 1000 grams of water the freezing point will be −1.86°C. What is the molecular weight of an alcohol (non-ionic) if a solution of 3 grams of it in 1000 grams of water freezes at −0.372°C.?

A. 5 grams per mole. **B.** 15 grams per mole.
C. 60 grams per mole. **D.** 167 grams per mole.
E. 372 grams per mole.

45. (3.00) Using what information you need from item number 44 determine what the freezing point of a 0.1 molal solution of the strong acid HCl would probably be. The answer is

A. 0°C. **B.** −0.186°C. **C.** −0.372°C.
D. −0.558°C. **E.** −1.86°C.

24. *Chemical Reactions and Energy Changes*

CHEMICAL REACTIONS AND ENERGY CHANGES

1. (1.10) If one unit volume of oxygen and two unit volumes of hydrogen are combined at high temperature and the water vapor formed is maintained at the same temperature, the number of unit volumes of water vapor obtained is

A. one. **B.** two. **C.** three.
D. a small fraction of one unit volume.
E. an indeterminate number of volumes greater than three.

2. (1.10) Chemical changes are always accompanied by

A. liberation of heat. **B.** absorption of heat.
C. energy changes. **D.** loss of weight.
E. heat and light.

3. (1.10) If heat energy is given off during an ordinary chemical reaction,

A. it is called activation energy.
B. the reaction is exothermic.
C. it is called atomic energy.
D. it will always start spontaneously.
E. the product formed will be very unstable.

4. (1.10) The reaction between sodium chloride and silver nitrate goes to completion because

A. a gas is formed. **B.** the reaction is reversible.
C. silver chloride does not ionize in solution.
D. silver chloride is insoluble.
E. sodium nitrate is more stable than silver nitrate.

5. (1.10) If products of a reaction provide the driving force to keep that reaction going, it is said to be

A. an equilibrium reaction. **B.** a chain reaction.
C. radioactive disintegration.
D. spontaneous combustion.
E. a photochemical reaction.

Items 6 - 16. After each item number on the answer sheet, blacken space

A. if the item at the left of the page is of greater magnitude than the item at the right.
B. if the item at the right of the page is of greater magnitude than the item at the left.
C. if the two items are of equal magnitude.

6. (1.10)	Amount of energy released when one gram of powdered iron burns in oxygen to iron oxide.	Amount of energy released when one gram of powdered iron rusts to iron oxide.
7. (1.10)	Extent to which compounds formed by electron sharing tend to ionize.	Extent to which compounds formed by electron transfer tend to ionize.
8. (1.10)	Mass of reacting substances.	Mass of new substances produced in the reaction.
9. (1.10)	Ease with which chloride ions give up electrons to form a free element.	Ease with which iodide ions give up electrons to form a free element.
10. (1.10)	Conductivity of an ionic compound dissolved in water.	Conductivity of a non-ionic compound dissolved in water.

11. (1.10)	Number of electrons lost in an oxidation-reduction reaction.	Number of electrons gained in the same oxidation-reduction reaction.
12. (1.10)	Malleability and ductility of a metal.	Malleability and ductility of a non-metal.
13. (1.10)	Velocity of reaction between two ionic solids.	Velocity at which the same two ionic solids will react when dissolved in water.
14. (1.10)	Effect of a 10°C. rise in temperature on the velocity of a given reaction.	Effect of a 20°C. rise in temperature on the velocity of the same reaction.
15. (1.10)	Velocity at which ionic compounds dissolved in water react together.	Velocity at which non-ionic compounds dissolved in water react together.
16. (1.10)	Number of electrons lost at the positive electrode in electrolysis.	Number of electrons gained at the negative electrode in electrolysis.

17. (1.10) The most likely reason why increase of temperature will increase the rate of a chemical reaction is that

A. an increase of temperature increases the valence of the reacting substances.
B. an increase of temperature increases the kinetic energy of the reacting molecules.
C. higher temperatures eliminate the products of a reaction.
D. heat acts as a catalyst.
E. an increase of temperature increases the time that the reacting molecules are in contact during any one collision.

Items 18 - 23 refer largely to various commercial processes used in manufacturing. For each item select from the key the technical name most closely related to it.

KEY

A. Cracking. **B.** Destructive distillation.
C. Fractional distillation. **D.** Synthesis.
E. None of these.

18. (1.10) A process for making charcoal.

19. (1.10) A process in which a solid is changed directly to a vapor and back to a solid.

20. (1.10) A process used for making ammonia at high temperature and pressure and in the presence of a catalyst.

21. (1.10) A process for separating fuel components which have different boiling points.

22. (1.10) A process used in the separation of iron from iron ore.

23. (1.10) A process for increasing the yield of gasoline from petroleum.

24. (1.10) A reaction will go to completion under all of the following conditions except when

A. an insoluble product is formed.
B. one product is a gas.
C. all products are precipitates.
D. the products are dissociated.
E. one product is inert.

25. (1.10) Which of the following statements regarding a chemical system in equilibrium is *never* true? At equilibrium

- **A.** the concentrations of the reactants are greater than the concentrations of the products.
- **B.** the forward reaction and the reverse reaction have both stopped.
- **C.** the concentrations of the reactants are less than the concentrations of the products.
- **D.** the rate of the forward reaction is equal to the rate of the reverse reaction.
- **E.** the concentrations of the reactants are equal to the concentrations of the products.

26. (1.10) A group of atoms within a molecule which are held together by sharing electrons and behave as a unit during a chemical reaction is termed

A. isoclinic. **B.** a compound. **C.** a radical.
D. a hydrocarbon. **E.** a hydrate.

27. (1.10) If heat energy is given off during an ordinary chemical reaction,

- **A.** the reaction always starts spontaneously.
- **B.** the product will be very unstable.
- **C.** it is called activation energy.
- **D.** disintegration of the nucleus occurs.
- **E.** the reaction is exothermic.

28. (1.10) Solution of a solute may hasten a chemical reaction because

- **A.** all solutes when dissolved become catalysts.
- **B.** the degree of subdivision increases surface area.
- **C.** undissociated water molecules are formed.
- **D.** equilibrium is quickly attained.
- **E.** all solutes ionize when dissolved.

29. (1.10) Some metals burn in pure oxygen but not in air because

- **A.** when in air, fewer oxygen molecules strike the metal.
- **B.** the average kinetic energy of air molecules is less than that of oxygen.
- **C.** the nitrogen in air smothers the flame.
- **D.** air is a poor conductor of heat.
- **E.** air has a high relative humidity.

30. (1.10) Which one of these statements is true when pure water is formed?

- **A.** Electrons are shared in the process.
- **B.** It is highly ionized.
- **C.** Protons are present in large numbers.
- **D.** It will conduct electricity.
- **E.** It contains two parts of hydrogen and one part of oxygen by weight.

31. (1.10) The rate of a chemical reaction may be conditioned by all of these factors except

A. heat. **B.** surface. **C.** time. **D.** catalyst.
E. concentration.

32. (1.10) All of these are methods for controlling the rate of chemical reactions except

A. time. **B.** surface. **C.** catalyst.
D. concentration. **E.** temperature.

33. (1.10) The first chemical process in the extraction of a metal from its sulfide ore is usually

- **A.** concentration of the metal bearing portion by grinding and screening.
- **B.** oxidation with air and heat.
- **C.** reduction with some reducing agent.
- **D.** fusion and electrolysis.
- **E.** treatment with sulfuric acid.

For items 34 and 35 select from the key the ore which is typically refined by the use of the material or process cited in the item.

KEY

- **A.** Copper ore (copper sulfide).
- **B.** Iron ore (iron oxide).
- **C.** Aluminum ore (aluminum oxide).
- **D.** Gold in quartz veins.

34. (1.10) Roasting. **35.** (1.10) Electric current.

For items 36 - 39 select from the key the ore which is typically refined by the use of the material or process cited in the item.

KEY

- **A.** Copper ore (copper sulfide).
- **B.** Iron ore (iron oxide).
- **C.** Aluminum ore (aluminum oxide).

36. (1.10) Coke and limestone. **37.** (1.10) Cryolite.

38. (1.10) Roasting. **39.** (1.10) Electric current.

40. (1.10) The electrolysis of water is a process of

A. neutralization. **B.** double decomposition.
C. oxidation-reduction. **D.** distillation.
E. dehydration.

41. (1.10) The reaction, given by the equation $HCl + NaOH \rightarrow NaCl + HOH$, will go to completion because

- **A.** ions of a product are removed from solution by the formation of a precipitate.
- **B.** one of the products leaves as a gas.
- **C.** undissociated water molecules are formed.
- **D.** $NaCl$ is soluble in water.
- **E.** it is a neutralization reaction.

42. (1.10) Some chemical reactions absorb heat, others give off heat. A reaction giving off heat

- **A.** proceeds only if heat is added.
- **B.** is termed idiomorphic.
- **C.** produces a product with a higher energy level than the reactants.
- **D.** usually forms a stable compound.
- **E.** will always start spontaneously.

43. (1.10) An electric current passing through brine (sea water) is used commercially to produce all of these *except*

A. Sodium chloride–$NaCl$. **B.** Hydrogen–H.
C. Chlorine–Cl. **D.** Sodium hydroxide–$NaOH$.

44. (1.10) A process for making ammonia at high temperature and pressure with an appropriate catalyst is known as

A. destructive distillation.
B. fractional crystallization. **C.** the Vorce process.
D. the Cottrell process. **E.** synthesis.

Item 45 deleted.

46. In the reduction of iron in industry, $CaCO_3$ is
(1.10)

A. an ore of iron. **B.** the slag. **C.** an impurity.
D. the flux. **E.** the electrolyte.

For items 47 - 49 use the following key:

KEY

A. Mg + S. **B.** Na + Cl. **C.** Na + S.
D. Cu + Cl. **E.** S + Cl.

47. Which combination of atoms forms ordinary salt?
(1.10)

48. Which combination of atoms forms a compound of low
(1.10) boiling point?

49. Which combination of atoms forms the most stable
(1.10) compound?

50. The smelting of hematite to produce iron requires
(1.10)

A. carbon and limestone. **B.** sulphur and electricity.
C. hydrogen and carbon.
D. carbon dioxide and sandstone. **E.** electricity.

Items 51 - 59. After each item number on the answer sheet, blacken space

A. if the item is true of the metallurgy of aluminum.
B. if the item is true of the metallurgy of iron.
C. if the item is true of the metallurgy of both.
D. if the item is true of the metallurgy of neither.

51. The metal is usually obtained from an ore which is an
(1.10) oxide of the metal.

52. The purified ore is dissolved in molten cryolite at the
(1.10) start of the process which yields the metal.

53. In changing from the ionic or combined state to the
(1.10) metallic state, each ion has accepted three electrons.

54. The metal produced from the ore usually does not re-
(1.10) quire further purification prior to its use.

55. Coke and limestone are used in the process.
(1.10)

56. Involves electrolysis of a salt of the metal in water
(1.10) solution.

57. The metal produced from the ore contains many im-
(1.10) purities and is weak and brittle.

58. The process is essentially one of reduction.
(1.10)

59. The process reduced the cost of the metal from over one
(1.10) hundred dollars a pound to a few cents per pound.

60. Which one of the following is produced commercially
(1.10) by passing an electric current through brine?

A. Sodium chloride. **B.** Oxygen.
C. Calcium hydroxide. **D.** Chlorine. **E.** Helium.

Items 61 - 63 refer to the reduction of ores. For each item select from the key the material or materials used in the process.

KEY

A. Carbon and limestone. **B.** Hydrogen and carbon.
C. Electricity only. **D.** Sulphur and electricity.
E. Carbon only.

61. Copper. **62.** Aluminum. **63.** Iron.
(1.10) (1.10) (1.10)

64. The chemical element essential in important explosives is
(1.10)

A. hydrogen. **B.** nitrogen. **C.** chlorine.
D. aluminum.

65. The greatest part of the *industrial* supply of oxygen is
(1.10) obtained by

A. the electrolysis of water.
B. the catalytic decomposition of potassium chlorate.
C. the fractional distillation of liquid air.
D. the separation of oxygen from air by diffusion.
E. the action of heat on oxides of the commoner metals.

66. A chemical explosion is always due to
(1.10)

A. union with oxygen. **B.** an endothermic change.
C. reactions between gases in which the volume of product is greater than volume of reactants.
D. scattering of inflammable dust in the air.
E. a rapid exothermic change.

67. Nitric acid
(1.10)

A. acts both as an oxidizing and a reducing agent.
B. is insoluble in water.
C. may be made by reducing ammonia.
D. is the acid of which N_2O is the anhydride.
E. can be produced, without oxidation-reduction change, by the action of H_2SO_4 on a nitrate.

68. If ammonium nitrate is heated, the principal product is
(1.10)

A. N_2. **B.** N_2O. **C.** NO. **D.** NO_2. **E.** N_2O_5.

69. In the cyanamide nitrogen fixation process,
(1.10)

A. no large energy demands are made.
B. the catalyst is made up, for the most part, of finely-divided iron.
C. high pressure is required.
D. the arc is spread by being passed over a magnetic field.
E. the final product is ammonia.

70. Carbon monoxide
(1.10)

A. neither burns nor supports combustion.
B. is with water vapor the main product of the combustion of gasoline.
C. owes part of its poisonous character to its high solubility in water.
D. is similar in density and boiling point to nitrogen.
E. yields one and a half times its own volume of carbon dioxide on combustion.

71. Caverns in limestone regions are formed
(1.10)

A. by the action of H_2CO_3 (CO_2 dissolved in water) on the $CaCO_3$ to form a soluble Ca $(HCO_3)_2$.
B. by the action of CO_2 on $Ca(OH)_2$.
C. by the formation of $CaCO_3$ when the pressure on solutions of $Ca(HCO_3)_2$ is lessened.
D. by the action of silicic acid in the ground waters upon $CaCO_3$.
E. by the action of limewater upon calcium carbonate.

72. In the nitrogen cycle
(1.10)

A. ammonium compounds are the only form of combined nitrogen that plants can assimilate.
B. certain types of plants, including peas and alfalfa, absorb nitrogen directly from the atmosphere.
C. nitrogen-fixing bacteria turn nitrites into ammonia.
D. animals excrete all their nitrogen as proteins.
E. fertilizers are necessary because about 5% of the nitrogen consumed by animals is not returned to the soil.

73. Metallic magnesium
(1.10)

A. is only acted upon by acids with oxidizing properties.
B. forms an oxide which reacts with water with extreme violence.
C. has a higher specific gravity than aluminum.
D. forms an amphoteric hydroxide.
E. can be made by reducing its oxide with carbon although the reaction is reversible.

74. In the iron blast furnace
(1.10)

A. entering air is preheated by the combustion of CO in the gas escaping from the furnace.
B. carbon acts directly to reduce the ferric oxide.
C. limestone is added to the charge to furnish CO_2 for the reducing process.
D. pure iron, at first formed, is thoroughly liquid, but it soon dissolves carbon, thereby becoming pasty.
E. the reduced iron is included in the slag which drops to the hearth, but it is released from this slag by the addition of deoxidizers.

75. Copper
(1.10)

A. remains bright in air owing to the formation of an invisible film of copper oxide.
B. reduces nitric acid to form nitrous oxide.
C. forms a green hydroxycarbonate in moist air.
D. forms sulfur trioxide with hot sulfuric acid.
E. is a very hard metal when highly purified.

76. In the open hearth steel furnace
(1.10)

A. iron oxide acts as an oxidizing agent.
B. if sulfur or phosphorus are present, the furnace must have an acidic lining.
C. spiegeleisen is added at the end of the operation to produce the desired carbon content.
D. only mild steel can be made by the process.
E. the furnace lining is always made of silica on account of its high melting point.

77. Concerning mercury,
(1.10)

A. at room temperature the vapor pressure of the metal is greater than that of water.
B. the metal may be purified by distillation.
C. of all the metals it is the most effective reducing agent.
D. the metal dissolves readily in HCl.
E. it is very difficult to extract the metal from its ores.

78. Consider the following six metals:
(1.10)

A. copper B. chromium C. manganese
D. sodium E. calcium F. magnesium

Which three of the above metals are obtained industrially from their ores by a process of electrolysis?

A. A, B, and C. **B.** A, D, and E.
C. C, D, and E. **D.** D, E, and F.
E. C, D, and F.

79. The equation $Zn(OH)_2 + 2HCl \rightarrow ZnCl_2 + 2H_2O$ may be classed as
(1.20)

A. decomposition. **B.** simple replacement.
C. simple combination. **D.** double decomposition.
E. none of these.

80. The equation $AgNO_3 + HCl \rightarrow HNO_3 + AgCl$ is a type of reaction known as
(1.20)

A. decomposition. **B.** neutralization.
C. simple combination. **D.** simple replacement.
E. double decomposition.

Items 81 - 85 deleted.

Items 86 - 90 refer to the general types of chemical reactions. For each item select from the key the correct classification.

KEY

A. Simple combination. **B.** Simple replacement.
C. Decomposition. **D.** Double decomposition.

86. $AgNO_3 + HCl \rightarrow AgCl + HNO_3$.
(1.20)

87. $Zn + 2HCl \rightarrow ZnCl_2 + H_2$.
(1.20)

88. $Cu + O_2 \rightarrow 2CuO$.
(1.20)

89. $2KClO_3 \rightarrow 2KCl + 3O_2$.
(1.20)

90. $Zn(OH)_2 + 2HCl \rightarrow ZnCl_2 + 2H_2O$.
(1.20)

For items 91 and 92 evaluate the statements according to the key:

KEY

A. Increasing the first increases the second.
B. Increasing the first decreases the second.
C. One remains practically constant regardless of change in the other.

91. The temperature of substances in a chemical reaction—rate of chemical reaction.
(1.22a)

92. The size of the particles of the substances in a chemical reaction—rate of chemical reaction.
(1.22a)

93. In a common laboratory method for the preparation of hydrogen from acids
(1.25)

A. no action takes place at room temperature.
B. zinc ions and chloride ions, in solution, are left in the generator.
C. the hydrogen evolved is dissolved in water, and this solution is commonly used in the subsequent experiments.
D. copper is added to concentrated sulfuric acid.
E. because of its poisonous qualities, the evolved gas should be collected under a hood.

94. Oxygen may be made by
(1.25)

A. heating iron oxide.
B. the action of zinc on HCl. **C.** heating PbO_2.
D. the action of HCl on MnO_2.
E. burning phosphorus in air.

95. Phosphate fertilizer (superphosphate)
(1.25)

A. is made by treating phosphate rock with chamber sulfuric acid.
B. is another name for phosphate rock.
C. formerly had to be secured from Germany, but is now obtainable from large deposits in Carlsbad, New Mexico.
D. never gives off protons.
E. without detriment to crops, may be replaced completely by fertilizers containing fixed nitrogen.

96. Phosphoric acid cannot be made by the action of water upon
(1.25)

A. P_2O_3. **B.** P_2O_5.
C. the substance produced by burning phosphorus in a large supply of air.
D. PCl_5.
E. the substance obtained when calcium phosphate, carbon and silica are heated in an electric furnace and the product is exposed to a free supply of air.

97. In the industrial preparation of phosphorus
(1.25)

A. carbon is used as a reducing agent.
B. the oxide is reduced with hydrogen.
C. the element settles to the bottom of the furnace and is drawn off as a slag.
D. a continuous stream of air is passed through the electric furnace.
E. sand is added to combine with the carbon monoxide produced in the reaction.

98. In the Haber process,
(1.25)

A. the action being exothermic, low temperatures are desirable.
B. the process is most effective if run at pressures less than one atmosphere.
C. nitric acid is the primary product.
D. the catalyst shifts the equilibrium point in a favorable direction.
E. all the raw materials needed come directly from the atmosphere.

99. Ammonia may be prepared effectively by
(1.25)

A. heating an ammonium salt.
B. passing air through an electric arc.
C. the transfer of protons from ammonium ions to hydroxide ions.
D. the Ostwald process.
E. the oxidation of nitric oxide.

100. Nitrogen may be obtained
(1.25)

A. by the action of OH^- ions on NH_4^+ ions.
B. by heating magnesium in the air.
C. by the oxidation of nitric acid.
D. by the electrolysis of a nitrate.
E. by heating a mixture of NH_4^+ ions and NO^-_2 ions.

101. Water gas
(1.25)

A. is made by heating SiO_2 with NaOH.
B. is made by the action of water on CaC_2.
C. unless carburetted, burns with a nonluminous flame.
D. contains more than 50% of nitrogen.
E. is mainly composed of methane.

102. Carbon dioxide is used upon a large scale
(1.25)

A. as a fuel gas. **B.** in the Solvay soda process.
C. as a reducing agent in the smelting of iron.
D. in the preparation of chlorine from sodium chloride.
E. in the production of caustic soda from soda ash.

103. Metallic sodium is commonly made by
(1.25)

A. electrolysis of fused NaCl, mixed with other chlorides to lower the melting point.
B. electrolysis of an aqueous solution of NaCl.
C. electrolysis of NaCl, dissolved in cryolite.
D. heating NaCl.
E. action of metallic aluminum on NaCl.

104. In the Solvay soda process
(1.25)

A. the action takes place in the electric furnace.
B. the success of the process depends upon the relatively small solubility in water of $NaHCO_3$.
C. by heating the by-product, NH_4Cl with calcium carbonate, ammonia is returned to the process.
D. no ionic actions are involved in the method.
E. to form soda ash from the first product of the process, the latter substance is treated with CO_2.

105. Permanent hardness
(1.25)

A. may be removed from water by adding sodium carbonate.
B. is due to a high concentration of sodium salts.
C. may be removed by adding calcium hydroxide.
D. is caused by the presence of calcium bicarbonate.
E. cannot be removed by zeolite filtration.

106. In the Hall process for extracting aluminum
(1.25)

A. the aluminum produced all comes from the cryolite of the bath.
B. clay is now generally used in the place of bauxite.
C. the released aluminum has a higher specific gravity than the liquid of the bath from which it is derived.
D. to keep the electrolyte in a fused condition, external heat must be supplied continually.
E. it is very seldom that the anodes must be renewed.

107. Hydrogen sulfide is usually prepared in the laboratory by
(1.25)

A. the reaction of hydrogen with hot sulfur.
B. the action of hydrochloric acid on iron sulfide.
C. the action of sulfuric acid on copper.
D. the action of an acid on a sulfite.
E. the reduction of sulfur dioxide by hydrogen at high temperatures.

108. In the contact sulfuric acid process
(1.25)

A. oxides of nitrogen are used as a catalyst.
B. very high temperatures are required.
C. the reaction goes on best in aqueous solution.

D. either platinum or compounds of vanadium may be used as catalysts.
E. the process of dissolving SO_3 in water offers no practical difficulties.

109. (1.25) Sulfur dioxide

A. is a stable compound whose density is almost equal to that of oxygen.
B. is obtained by the combustion of iron pyrites.
C. yields a monoprotic acid when it dissolves in water.
D. is liquefied only with great difficulty.
E. contains sulfur with an oxidation state of +2.

111. (1.30) $Fe + H_2O \rightarrow Fe_3O_4 + H_2$
When properly balanced the number of molecules of H_2O in the equation will be

A. 2. **B.** 4. **C.** 6. **D.** 8. **E.** 10.

112. (1.30) $NO_2 + H_2O \rightarrow HNO_3 + NO$
Which one of the following sets of numbers when placed in the same order in the above equation causes it to be correctly balanced?

A. 1, 2, 3, 4. **B.** 1, 2, 2, 1. **C.** 2, 1, 2, 2.
D. 3, 1, 2, 1. **E.** 3, 2, 1, 2.

113. (1.30) The expression $4FeCO_3 + O_2 \rightarrow 2Fe_2O_3 + CO_2$ is not considered a balanced chemical equation until it conforms with

A. the law of multiple proportions.
B. the law of definite proportions.
C. Avogadro's Law.
D. the rules for reversible reactions.
E. the law of conservation of matter.

114. (1.30) When a chemical equation is properly balanced

A. the sum of the coefficients on one side will equal the sum of the coefficients on the other side of the equation.
B. there will be the same number of molecules on each side of the equation.
C. the quantity of matter indicated on one side of the equation will equal that indicated on the other.
D. it always represents an equilibrium reaction.
E. none of these is true.

115. (1.30) In an experiment on the synthesis of water by weight, a quantity of copper oxide was heated in a stream of hydrogen and the water product of the reaction collected by a tube of calcium chloride which readily absorbs water. The following data were collected·

Loss in weight of the CuO: 2.4 gm.
Gain in weight of the $CaCl_2$: 2.7 gm.

The residue in the copper oxide reaction was probably

A. $Cu(OH)_2$. **B.** $CuCl_2$. **C.** Cu. **D.** CaO.
E. H_2O.

116. (2.10) In the preceding experiment, the weight of hydrogen involved was

A. 0.3 gm. **B.** 2.4 gm. **C.** 2.7 gm. **D.** 5.1 gm.
E. impossible to calculate.

117. (3.00) In the experiment of item 115, the weight ratio of oxygen to hydrogen was

A. 2.7 to 2.4. **B.** 2.7 to 0.3. **C.** 2.0 to 1.0.
D. 2.4 to 0.3. **E.** 16 to 1.

Items 118 - 120 refer to the combustion of pentane, C_5H_{12}, the complete combustion of which yields CO_2 and H_2O as the only products.

118. (1.30) How many carbon dioxide molecules are formed from each molecule of pentane?

A. 1. **B.** 2. **C.** 3. **D.** 4. **E.** 5.

119. (1.30) How many water molecules are formed from each molecule of pentane?

A. 6. **B.** 12. **C.** 3. **D.** 4. **E.** 5.

120. (1.30) How many atoms of oxygen are needed for complete combustion of one molecule of pentane?

A. 17. **B.** 11. **C.** 6. **D.** 10. **E.** 16.

121. (1.30) Why does a neutralization reaction, for example, that between HCl and NaOH, go to completion?

A. a catalyst is present.
B. HCl is a strong acid and NaOH is a strong base.
C. Water is a relatively un-ionized substance.
D. Sodium chloride is a stable salt.
E. Sodium chloride yields Na^+ and Cl^- ions.

122. (1.30) Some chemical reactions give off heat as they proceed, others absorb heat. A reaction giving off heat

A. usually forms a stable compound.
B. will always start spontaneously.
C. always contains carbon.
D. produces a product with a higher energy level than the reactants.
E. is endothermic

123. (1.30) Which of the following statements regarding a chemical system in equilibrium is *never* true?

A. The concentrations of the reactants are greater than the concentrations of the products.
B. The forward reaction and the reverse reaction have both stopped.
C. The concentrations of the reactants are less than the concentrations of the products.
D. The rate of the forward reaction is equal to the rate of the reverse reaction.
E. The concentrations of the reactants are equal to the concentrations of the products.

124. (1.30) The equation $HgO \rightarrow Hg + O_2$ is not correct because it does not follow the Law of

A. Definite Proportions. **B.** Avogadro.
C. Multiple Proportions. **D.** Gay Lussac.
E. Conservation of Mass.

Item 125 deleted.

126. (1.30) Balance the equation $H_2S + O_2 \rightarrow H_2O + SO_2$ and count the number of molecules in the *entire* equation. The answer is

A. 4. **B.** 18. **C.** 5. **D.** 9.
E. none of these.

127. (1.30)
a. $H_2SO_4 + P_2O_5 \rightarrow SO_3 + 2HPO_3$.
b. $Na_2SO_3 + S \rightarrow Na_2S_2O_3$.
c. $Mg + O_2 \rightarrow 2MgO$.
d. $NaCl + H_2SO_4 \rightarrow HCl + NaHSO_4$.
e. $H_2SO_3 + Cl_2 \rightarrow H_2SO_4 + 2HCl$.

One of the above equations as written does not conform to the

A. law of Gay Lussac.
B. law of conservation of energy.
C. law of accordant junction.
D. law of conservation of mass. **E.** harmonic law.

128. (1.30) That equation (in reference to item 127) is

A. a. **B.** b. **C.** c. **D.** d. **E.** e.

129. (1.30) Balance the equation $FeCl_3 + NaOH \rightarrow Fe(OH)_3 + NaCl$. The sums of the coefficients on the left and right sides respectively are

A. 2 - 2. **B.** 3 - 3. **C.** 4 - 4. **D.** 3 - 4.
E. none of these combinations.

130. (1.30) The statement, "The total mass of the products of a chemical reaction is always the same as the total mass of original material," is another way of stating

A. the law of conservation of energy.
B. that matter can be neither created nor destroyed.
C. the law of definite proportions. **D.** a gas law.
E. that the combination of one element with another always takes place between a definite number of each kind of atoms.

131. (1.30) Which one of these is an endothermic process?

A. Heating potassium chlorate to obtain oxygen.
B. Burning fuel oil.
C. Compressing the gas in an electric refrigerator.
D. Adding an acid to a base to form a salt.
E. Sharpening a lead pencil.

Items 132 - 137 are concerned with the factors which determine the speed of chemical reactions. For each item select from the key the most appropriate factor which relates to the statement.

KEY

A. Temperature. **B.** Surface. **C.** Catalyst.
D. Concentration.

132. (1.30) The molecules are in more rapid motion, therefore, more collisions take place per unit time.

133. (1.30) It is the most common way of controlling reactions.

134. (1.30) The finer the division of the substances, the more rapidly they take part in the reaction.

135. (1.30) The reaction takes place in the presence of small amounts of other substances which apparently remain unchanged.

136. (1.30) Solids are often dissolved in liquids to obtain a high degree of subdivision and________.

137. (1.30) The finer the division of the substances, the more rapidly they take part in the reaction. Which one of the factors determining the speed of chemical reactions does the preceding statement refer to?

138. (1.30) When hydrogen gas is passed over heated cupric oxide

A. cupric hydride is formed.
B. hydrogen peroxide forms.
C. a red solid and a colorless liquid are produced.
D. cupric hydroxide forms.
E. no action takes place.

139. (1.30) When a candle is burned completely in air, the carbon dioxide and water produced have a weight, compared with that of the candle, which is

A. the same. **B.** less.
C. sometimes greater, sometimes less, depending upon the temperature.
D. CO rather than CO_2 is formed by the combustion of a candle.
E. greater.

140. (1.30) The principle of Le Chatelier

A. says that when a system in equilibrium is subjected to strain, the stress will move in the direction of equilibrium.
B. accounts for the speeding up of chemical reactions at high temperatures.
C. says that stress must equal strain.
D. explains why high pressures are used in the industrial synthesis of ammonia.
E. explains why high pressures alone will not liquefy air.

141. (2.10) Given the equation $N_2 + 3H_2 \rightarrow 2NH_3$. Under standard conditions, the number of liters of hydrogen needed to produce 10 liters of ammonia is

A. 3.3. **B.** 5.0. **C.** 10.0. **D.** 15.0.
E. none of these.

142. (2.10) If sulfur is burned as shown by the equation $S + O_2 \rightarrow SO_2$, the number of pounds of SO_2 obtained by burning 5 pounds of sulfur with 5 pounds of oxygen is

A. 5. **B.** 10. **C.** 15. **D.** 60.
E. none of these.

143. (2.10) The reaction for burning hydrogen at a temperature high enough to produce water in the gaseous state is given by the equation $2H_2 + O_2 \rightarrow 2H_2O$. The number of liters of water vapor formed from 50 liters of hydrogen will be

A. 50. **B.** 100. **C.** 150. **D.** 200.
E. none of these.

144. (2.10) The number of grams of hydrogen in 60 grams of methane CH_4, is

A. 15 grams. **B.** 20 grams. **C.** 5 grams.
D. 3.75 grams. **E.** none of these.

145. (2.10) The system containing CO_2 (carbon dioxide) and H_2CO_3 (carbonic acid) in a water solution is said to be in a state of equilibrium when

A. the solution will not affect litmus.
B. the amounts of CO_2, H_2O, and H_2CO_3 are equal.
C. the H_2CO_3 is forming and decomposing at equal rates.
D. the amounts of CO_2, H_2O, and H_2CO_3 are proportional to their molecular weights.
E. a minimum number of ions remains in the solution.

146. (2.10) Iron reacts with sulfur as given by the equation, $Fe + S \rightarrow FeS$. The approximate atomic weight of iron = 56, of sulfur = 32. The number of grams of FeS obtained from 100 gm. of S is approximately

A. 57. **B.** 175. **C.** 275. **D.** 157. **E.** 36.

147. The complete combustion of acetylene is represented by
(2.10) the following equation: $2C_2H_2 + 5O_2 \rightarrow 4CO_2 + 2H_2O$. How many cubic feet of pure oxygen would be necessary for the complete combustion of 10 cubic feet of acetylene if both gases were measured under the same conditions?

A. 25. **B.** 50. **C.** 20. **D.** 40.
E. none of these.

148. Methane burns according to the equation: $CH_4 +$
(2.10) $2O_2 \rightarrow CO_2 + 2H_2O$. The amount of water vapor produced in burning 1000 cu. ft. of methane is

A. 500 cu. ft.
B. 250 cu. ft.
C. 1000 cu. ft.
D. 2000 cu. ft.
E. 4000 cu. ft.

C	12
O	16
H	1

149. If one unit of oxygen and two unit volumes of hydro-
(2.10) gen are combined at high temperature and the water vapor formed is maintained at the same temperature, the number of unit volumes of water vapor obtained is

A. one. **B.** two. **C.** three.
D. a small fraction of one unit volume.
E. an indeterminate volume greater than three.

150. Methane burns according to the equation $CH_4 + 2O_2 \rightarrow$
(2.10) $CO_2 + 2H_2O$. The volume of CO_2 produced in burning 100 liters of methane is

A. 50 liters. **B.** 274 liters. **C.** 33.3 liters.
D. 220 liters. **E.** none of these.

For items 151 - 154 choose from the key list of word and formula equations the one most closely related to the statements.

KEY

A. $CO_2 + H_2O \rightarrow H_2CO_3$
carbon dioxide water carbonic acid

B. $NaOH + H_2CO_3 \rightarrow$
sodium hydroxide carbonic acid

$Na_2CO_3 + 2H_2O$
sodium carbonate water

C. $CaCO_3 + 2HCl \rightarrow$
calcium carbonate hydrochloric acid

$CaCl_2 + CO_2 + 2H_2O$
calcium chloride carbon dioxide water

D. $NaHCO_3 + HC_2H_3O_2 \rightarrow$
sodium bicarbonate acetic acid

$NaC_2H_3O_2 + H_2CO_3$
sodium acetate carbonic acid

E. $Ca(HCO_3)_2 \rightarrow CaCO_3 +$
calcium bicarbonate calcium carbonate

$CO_2 + H_2O$
carbon dioxide water

151. This reaction could be the first step in a process used
(2.10) in the baking industry.

152. This reaction may be the final one in the formation of
(2.10) stalactites.

153. Using known materials this is a good reaction to estab-
(2.10) lish a test for carbonates.

154. Under ordinary conditions, this equation would show
(2.10) the least tendency to go to completion.

The following paragraph applies to items 155 and 156.

Some common chemical reactions demonstrating the principle of chemical energy are:

a. the burning of coal
$C + O_2 \rightarrow CO_2 + 84{,}400$ cal.
b. neutralization
$NaOH + HCl \rightarrow NaCl + H_2O + 13{,}700$ cal.
c. ionization of salts
$KNO_3 + 8{,}500$ cal. $\rightarrow K^+ + NO_3^-$
d. decomposition of water
$2H_2O + 116{,}800$ cal. $\rightarrow 2H_2 + O_2$

155. In the list of reactions given above, those which are
(2.10) examples of endothermic reactions are

A. a and b. **B.** a and c. **C.** b and c and d.
D. b and d. **E.** c and d.

156. In the list of examples given above, those which are
(2.10) examples of exothermic reactions are

A. a and b. **B.** a and c. **C.** b and c and d.
D. b and d. **E.** a and c and d.

157. The ionization of KNO_3, when it is dissolved in water,
(2.10) is as follows:

$KNO_3 + 8{,}500$ cal. $\rightarrow K+ + NO^-_3$

From this, then, which of the following would be most nearly correct?

A. The water will become warmer due to the reaction.
B. Heat is given off to the surrounding media.
C. The beaker will become cooler.
D. 8,500 calories will be given off during the ionization of 1 gram-molecular weight of KNO_3.
E. ionized $K^+NO_3^-$ contains less energy than molecular KNO_3.

158. If it took one hour for a certain chemical reaction to
(2.10) take place at 110°C., at 130°C. it should take approximately

A. 10 minutes. **B.** 15 minutes. **C.** 30 minutes.
D. 40 minutes. **E.** 50 minutes.

Items 159 - 162 refer to the following paragraph. After each exercise number on the answer sheet, blacken the *one* lettered space which designates the correct answer.

At the Dow Chemical Company plant at Freeport, Texas, magnesium is extracted from the sea. The magnesium ions in sea water are precipitated as $Mg(OH)_2$, converted to the salt $MgCl_2$, and in the final step, melted $MgCl_2$ is electrolyzed.

(Note: Mg is in group II of the periodic table. Compared to a few other elements it stands in the activity series as Na, Mg, H, Cu.)

159. Magnesium hydroxide is
(2.10)

A. a soluble salt. **B.** a soluble base.
C. an insoluble acid. **D.** an insoluble salt.
E. an insoluble base.

160. (1.30) Mg metal appears during the electrolysis because

A. magnesium ions receive electrons.
B. magnesium ions lose electrons.
C. hydrogen in water replaces the magnesium.
D. $MgCl_2$ is held together by a covalent bond.
E. sodium replaces the magnesium.

161. (1.10) During electrolysis magnesium metal appears

A. at the anode or positive electrode.
B. in the external circuit.
C. in an aqueous solution.
D. at the cathode or negative electrode.

162. (1.10) Which of the following is released at the anode during the electrolysis?

A. Hydrogen. **B.** Magnesium. **C.** Chlorine.
D. Oxygen. **E.** Magnesium hydroxide.

163. (2.10) When sodium peroxide reacts with water

A. sodium hydroxide is produced and oxygen is evolved.
B. the mixture must be heated to the boiling point to start the reactions.
C. the products are sodium monoxide and oxygen.
D. hydrogen gas is evolved rapidly.
E. the rate of the action is too slow to make it of practical utility.

164. (2.10) The equation which represents satisfactorily the result of heating potassium chlorate is

A. $KClO_3 \rightarrow KClO + O_2$.
B. $KClO_4 \rightarrow KCl + 2\ O_2$.
C. $2\ KClO_3 \rightarrow 2\ KCl + 3\ O_2$.
D. $KClO_3 \rightarrow KCl + O_3$.
E. $2\ KClO_3 \rightarrow 2\ KClO + 2\ O_2$.

165. (2.10) Nitric acid is prepared by the following reaction:

A. $NaNO_3 + HCl \rightarrow NaCl + HNO_3$.
B. $NaNO_3 + H_2SO_4 \rightarrow NaHSO_4 + HNO_3$.
C. $N_2O + H_2O \rightarrow 2O_2 + 2\ HNO_3$.
D. $NH_3 + 3\ H_2O \rightarrow HNO_3 + 4\ H_2$.
E. None of the above reactions.

166. (2.20) If heat energy is absorbed during an ordinary chemical change

A. the reaction will proceed spontaneously.
B. the reacting substances will become cold.
C. the process is spoken of as being isothermic.
D. the reacting substances will "burn."
E. that chemical change is of little practical importance.

167. (2.20) Photosynthesis is an endothermic reaction because it

A. produces a soluble product.
B. utilizes carbon dioxide as a raw material.
C. produces oxygen as an end product.
D. goes on (continues) only in the presence of light.
E. goes on only within living plant organisms.

Items 168 - 174 refer to the following paragraphs.

Many chemical reactions, like the tarnishing of metals such as copper, proceed very slowly, taking months or even years, but others may proceed at an explosive rate. One factor affecting the speed of reactions is concentration of the substances, i.e., the quantity of material per unit volume. Some metals dissolve more slowly in dilute acids than in concentrated acids. Substances burn more rapidly in pure oxygen than in air. Increasing the concentration increases the speed of reaction.

The kinetic-molecular theory is used to explain the effect of concentration upon speed of reaction. Gases consist of tiny molecular particles, in constant motion, and separated from each other by vast spaces relative to their size. In liquids, the particles move freely but they have very little space between them. In solids, the molecules merely vibrate about some fixed position.

From this theory, it becomes reasonable to think that for a reaction to take place, molecules of substances must come into contact. If by some change in conditions, the number of collisions per unit time increases, the reaction rate increases. Thus, if the concentration is increased, more collisions occur, and the speed of reaction increases. In gases, increasing the pressure increases the concentration, but in liquids an increase in pressure has little effect because the volume of a liquid cannot be changed readily. This is true also of solids. In the case of solutions, we may dissolve more of a substance in the same amount of solvent to increase the concentration.

Temperature also affects the speed of chemical reactions. On the average, a 10°C. rise in temperature will double the speed of reaction. It is a well known fact that fuels such as coal and wood must be heated (lighted) before they will burn. When ordinary fuels start to burn they generate sufficient heat for the reaction to continue. Some reactions absorb heat and will not continue unless heat from an outside source is supplied.

168. (2.20) The paragraphs above imply that

A. heavy metals like lead rust more rapidly than a light metal such as magnesium.
B. all metals will rust.
C. increased pressure will increase the rate of solution of a metal in strong acid.
D. at high temperatures, copper foil may oxidize in a few minutes.
E. all metals will burn in oxygen.

169. (2.20) Changes in pressure have only a slight effect on reactions between solids. The best explanation of this is that

A. solids are only slightly reactive.
B. in solids, molecular freedom is limited.
C. solids are not appreciably compressible.
D. solid molecules move very slowly.
E. solids are not reactive.

170. (2.20) A heavy iron wire will burn in pure oxygen but not in air because

A. in air, carbon dioxide acts as a fire extinguisher.
B. in air, there are too few collisions per second with oxygen molecules.
C. in air, the nitrogen molecules smother the flame.
D. in pure oxygen, the molecules move faster.
E. in pure oxygen, there is no water vapor present.

171. (2.20) An effective way to increase the number of molecular collisions, besides that of increasing the concentration is to

A. increase the velocity of the molecules.
B. increase the mass of the molecules.
C. reduce the temperature of the molecules.
D. increase the size of the molecules.
E. decrease the kinetic energy of the molecules.

172. (2.20) Which one of the following is true in the comparison of a liquid and a solid at the same temperature?

A. Liquid molecules have a greater degree of freedom.
B. Heat must be applied to make the molecules of a solid move.
C. Liquid molecules vibrate about a fixed position.
D. There is less space between the molecules of a liquid.
E. Liquid molecules are more dense.

173. (2.20) For a reaction to take place, it is necessary that

A. the molecules be in the form of a gas.
B. the substance must be under a high pressure.
C. a force of attraction exist between the molecules.
D. the molecules collide.
E. the molecules move at their maximum speed.

174. (2.20) Two substances which absorb heat when they react are heated until the reaction occurs at a fairly rapid rate. If the heat source is removed

A. the speed of the reaction will increase due to the increase in concentration.
B. the reaction will be explosive.
C. the speed of the reaction will decrease.
D. the speed of the reaction will remain unchanged.
E. the temperature will rise.

Items 175 - 178. Select your answer from the key.

KEY

A. Al^{+++} **B.** $O^{=}$ **C.** Al **D.** O

The following process is used in the commercial production of aluminum:

$$2\overset{+++}{Al_2}\overset{=}{O_3} + \text{Direct Current} \rightarrow 4Al + 3O_2$$

175. (2.20) The substance that loses electrons.

176. (2.20) The substance that gains electrons.

177. (2.20) The product liberated at the cathode.

178. (2.20) The product formed at the anode.

Items 179 - 189. The following factors influence the velocity of chemical reactions, causing a reaction to take place more rapidly or more slowly. After each item on the answer sheet, blacken space

A. if the factor is change in temperature.
B. if the factor is change in concentration of the reactants.
C. if the factor is alteration in size of particles, or change in total surface exposed.
D. if the factor is a catalyst (positive or negative).
E. if the factor is the nature of the substance (reactive or non-reactive).

179. (2.20) Food materials are chemically changed with release of energy in living cells, but at a temperature much lower than when burned in air.

180. (2.20) Very finely powdered pure iron will ignite when thrown out into the air.

181. (2.20) Magnesium reacts very slowly with water, while sodium reacts much more rapidly.

182. (2.20) Rain water containing carbonic acid dissolves limestone forming a solution of calcium bicarbonate, $Ca(HCO_3)_2$. As this solution drops from the roof of a cave, its evaporation results in loss of carbonic acid from the solution and deposition of $CaCo_3$ as stalactites and stalagmites.

183. (2.20) Friction causes automobile tires to deteriorate more rapidly.

184. (2.20) Hydrogen peroxide rapidly decomposes into water and oxygen when a small amount of powdered manganese dioxide is added.

185. (2.20) Dirigibles and other lighter-than-air craft are much safer when filled with helium.

186. (2.20) Many chemical reactions occurring in water solutions can be made to proceed more slowly by adding water.

187. (2.20) When molecules move faster, collisions occur more frequently, thus increasing opportunities for reaction.

188. (2.20) Acetanilide is used to inhibit the decomposition of hydrogen peroxide.

189. (2.20) A glowing splint burns faster when placed in a bottle of pure oxygen.

190. (2.20) Sulfuric acid expels hydrogen chloride from its salts because sulfuric acid, as compared with HCl is

A. less volatile. **B.** denser. **C.** a stronger acid.
D. a stronger oxidizing agent.
E. diprotic instead of monoprotic.

Items 191 - 195 refer to magnitude of the changes suggested by the statement. For each item select from the key the most appropriate response.

KEY

A. Twice as great. **B.** Three times as great.
C. Four times as great. **D.** Nine times as great.
E. Unchanged.

191. (2.30) The effect upon the resistance of an electric circuit of using a wire 2 mm. in diameter in place of a wire 4 mm. in diameter.

192. (2.30) The effect upon the speed of the electroplating process of moving the anode from a position 9 cm. from the cathode to a position 3 cm. from the cathode.

193. (2.30) The effect upon the voltage in a household circuit of changing from a 50 watt bulb to a 200 watt bulb.

194. (2.30) The average effect upon reaction rate in a chemical reaction of an increase in temperature of 10°C.

195. (2.30) The effect upon illumination of moving an object which is 6 feet from the source of light to a distance 3 feet from the same source.

For items 196 - 200 select from the key the theory, law, or discovery developed from the given observation.

KEY

A. Law of Definite Proportions. **B.** Electron.
C. Bohr Theory. **D.** Law of Multiple Proportions.
E. Kinetic Theory.

196. (2.40) Reactions between gases, such as

$$N_2 + O_2 \rightarrow 2NO$$
$$N_2 + 2O_2 \rightarrow 2NO_2$$

197. A spark was sent through a tube from which a high
(2.40) percentage of air had been pumped out. If zinc sulfide powder was placed inside the tube, an illuminated beam streaked between the terminals.

198. The fact that atoms emit light as shown by bright-line
(2.40) spectra.

199. Proust stated, "The cinnabar (HgS) of Japan has the
(2.40) same properties and composition as that of Spain. Silver chloride is identical whether obtained in Peru or Spain."

200. An electric spark is passed through a mixture containing
(3.00) 16 grams of oxygen gas and 4 grams of hydrogen gas. After the explosion, there is in the container

A. 16 grams of water and 4 grams of hydrogen.
B. 8 grams of water and 12 grams of oxygen.
C. 6 grams of water and 14 grams of oxygen.
D. 20 grams of water.
E. 18 grams of water and 2 grams of hydrogen.

Items 201 - 210. The better known metallic elements are arranged at the right in the "activity series." After each item number on the answer sheet, blacken space

A. if the item is true of sodium (Na).
B. if the item is true of aluminum (Al).
C. if the item is true of iron (Fe).
D. if the item is true of hydrogen (H).
E. if the item is true of silver (Ag).

K
Na
Ca
Mg
Al
Zn
Fe
Sn
H
Cu
Hg
Ag
Au

201. This element displaces only gold (Au) from its
(3.00) compounds.

202. When mixed in powdered form with iron oxide
(3.00) and ignited (the thermite process), this metal replaces the iron in the oxide.

203. This element releases hydrogen rapidly even
(3.00) from cold water.

204. Calcium (Ca) would displace this metal from its salts,
(3.00) but zinc (Zn) would not.

205. This element releases hydrogen from acids, but less
(3.00) readily than any of the other metals listed above.

206. This metal will not displace hydrogen from HCL.
(3.00)

207. This element has the greatest tendency of those listed
(3.00) to lose electrons and to become a positive ion.

208. The ions of this element have the greatest tendency of
(3.00) those listed to take electrons and thereby turn back into the metal.

209. This element would be more likely than any other to
(3.00) be found in nature in elementary form.

210. Ions of this element can take electrons from tin (Sn)
(3.00) but not from mercury (Hg).

211. a. $CO_2 + H_2O \rightarrow H_2CO_3$.
(3.00) b. $2KClO_3 \rightarrow 2KCl + 3O_2$.
c. $3\,Fe + 4H_2O \rightarrow Fe_3O_4 + 4H_2$.
d. $2KBr + 3H_2SO_4 + MnO_2 \rightarrow 2KHSO_4 + MnSO_4 + 2H_2O + Br_2$.

Which of the following choices lists all and only the above equations which are correctly balanced?

A. abcd. **B.** abc. **C.** bcd. **D.** acd. **E.** ab.

212. For the reaction $Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O$,
(3.00) which one of these is true?

A. The reaction will reach a state of equilibrium rather than completion.
B. The reaction will not reach completion because ions of a product are removed by formation of undissociated water molecules.
C. Completion is achieved because one of the products leaves as a gas.
D. The reactions will not form the desired products.
E. The reaction will be completed because a precipitate is formed.

213. Element X has an atomic number of 12, and element Y
(3.00) has an atomic number of 17. When they react, exerting their usual valences, we get

A. XY. **B.** X_2Y. **C.** X_2Y_3. **D.** X_3Y_2.
E. XY_2.

214. When aluminum combines with oxygen, considerably
(3.00) more heat per gram of oxygen is given off than when iron combines with oxygen. If a mixture of aluminum and iron oxide is strongly heated, a reaction

A. will proceed with the evolution of heat.
B. will proceed with the absorption of heat.
C. will not proceed.
D. may or may not take place, depending upon the nature of the oxides.

215. The basis for the prediction in the preceding item is
(1.30) that

A. iron is more active than aluminum.
B. iron is above aluminum in the electromotive series.
C. more heat is given off in the formation of aluminum oxide than is required to decompose the iron oxide.
D. less heat is given off in the formation of the aluminum oxide than is required to decompose the iron oxide.
E. an equilibrium may shift to the right or to the left by the use of appropriate methods.

216. The reaction $X + Y \rightarrow Z$ proceeds rapidly; the reverse
(3.00) reaction $Z \rightarrow X + Y$ proceeds more slowly under the same conditions. It follows, therefore, that

A. at equilibrium the rate of the first reaction will be greater than that of the second reaction.
B. at equilibrium the concentrations of X and Y are less than that of Z.
C. at equilibrium the concentrations of X and Y are greater than that of Z.
D. an equilibrium will be established slowly.
E. an equilibrium will be impossible to establish.

217. When magnesium burns to form magnesium oxide, MgO,
(3.00) two grams of oxygen combine with three grams of magnesium. If a six gram sample of magnesium is burned in a closed container which contains three grams of oxygen

A. no reaction will occur. **B.** Mg_2O will be formed.
C. MgO_2 will be formed.
D. some magnesium will be left over.
E. the magnesium oxide will contain a lower percentage of oxygen.

Items 218 - 220 refer to the electromotive series. In the series, hydrogen is listed at zero potential. Above hydrogen the potentials increase positively and below it the potentials increase in the negative sense, e.g., Al has a potential of 1.67 while gold has a potential of —1.68. Zn will displace H from dilute acids and Zn will displace Ag from salts of Ag. The tendency to go to the reduced state increases as one proceeds from top to bottom in the series while the tendency to go to the oxidized state increases from gold to sodium.

218. In chemical reaction one might predict that
(3.00)

A. Cu will displace H from acids.
B. Cu will displace Pb from Pb salts.
C. H with zero potential is inert.
D. Sn will displace Cu from Cu salts.
E. Au is more readily oxidized than Al.

219. The positions of gold and sodium indicate that
(3.00)

A. gold is relatively soft, sodium is not.
B. sodium is non-metallic, gold is not.
C. sodium has a complete outer ring of electrons, gold does not.
D. gold is resistant to corrosion, sodium is not.
E. sodium is an integral part of acid salts, gold is not.

Partial List
of Series

Na—sodium
Mg—magnesium
Al—aluminum
Zn—zinc
Fe—iron
Sn—tin
Pb—lead
H—hydrogen
Cu—copper
Ag—silver
Au—gold

220. Which one of the following expressions is impossible according to the theory of the electromotive series? (Some of these may not be balanced.)
(3.00)

A. $Zn + SnCl_2 \rightarrow ZnCl_2 + Sn$.
B. $Fe + AlCl_3 \rightarrow FeCl_3 + Al$.
C. $Na + H_2O \rightarrow NaOH + H_2$.
D. $Zn + Cu \rightarrow Zn^{++} + Cu$.
E. None of the above is impossible.

221. An exothermic compound is a compound which is formed from its constituent elements by a reaction which evolves heat. An endothermic compound is a compound which is formed from its constituent elements by a reaction which absorbs heat. A burning splint continues to burn in N_2O gas but is extinguished by NO gas. (The oxygen for the combustion results from decomposition of N_2O). It follows from this that
(3.00)

A. N_2O is an exothermic compound and NO an endothermic compound.
B. N_2O is an endothermic compound and NO an exothermic compound.
C. N_2O is an exothermic compound but the data are insufficient to prove the exothermic or endothermic character of NO.
D. The above data do not prove the exothermic or endothermic character of those compounds one way or the other.

For items 222 - 226 choose from the key list the information that would be most helpful in explaining the following situations.

KEY

A. The rate of a chemical reaction depends upon the concentration of materials entering into the reaction.
B. Catalysts affect the rate of chemical reactions.
C. The rate of a reaction depends upon the area of contact between the reacting materials.
D. Temperature affects the rate of chemical reactions.
E. If a state of equilibrium is upset, there is a tendency to restore a state of equilibrium.

222. Gasoline is converted to a vapor before being injected into the cylinders of an automobile engine.
(3.00)

223. A safety precaution requires that all grease be carefully removed from around the valves of cylinders of compressed oxygen.
(3.00)

224. Aluminum metal can be used for constructing objects that are exposed to high temperatures and yet aluminum foil can be used in flash bulbs.
(3.00)

225. An oxygen-hydrogen flame is hotter than a hydrogen-air flame.
(3.00)

226. Tetraethyl lead is added to gasoline in small amounts to improve its combustion properties.
(3.00)

227. In the formation of CaO, the relative combining weights are 5 gm. of Ca to 2 gm. of O. If 10 gm. of Ca and 6 gm. of O are taken for the experiment
(3.00)

A. no reaction should occur.
B. the per cent of oxygen in the CaO would be greater.
C. CaO_2 should be formed.
D. some oxygen is left after CaO is formed.
E. the extra oxygen acts as a catalyst.

228. From the equation $C + O_2 = CO_2 + 96.82$ kcal. it can be inferred that, if the atomic weights of carbon and oxygen are 12 and 16 respectively, the combustion of 36 grams of carbon will produce
(3.00)

A. 44 grams of CO_2 and 96.82 kcals. of heat.
B. 132 grams of CO_2 and 96.82 kcals. of heat.
C. 88 grams of CO_2 and 290.46 kcals. of heat.
D. 132 grams of CO_2 and 290.46 kcals. of heat.
E. 132 grams of CO_2 and 193.64 kcals. of heat.

229. When potassium chlorate is heated, it decomposes according to the equation heat $+ 2KCLO_3 \rightarrow 2KCl + 3O_2$.
(3.00)

Which of the following inferences may be drawn most safely?

A. After $KClO_3$ has decomposed, further heat will decompose KCl.
B. Oxygen-containing compounds usually lose oxygen on heating.
C. Cooling a mixture of KCl and O_2 will result in the formation of $KClO_3$.
D. $KClO_3$ has more kinetic energy than KCl.
E. The resulting mixture of KCl and O_2 has more potential energy than $KClO_3$.

230. The point of equilibrium in a chemical reaction is dependent on
(4.10)

A. the state of subdivision of the reactants.
B. the temperature at which the reaction takes place.
C. the presence or absence of a catalyst.
D. the time to reach a state of equilibrium.
E. none of the above.

231. How many pounds of pure magnesium could be obtained by the electrolysis of 2000 pounds of molten magnesium chloride, $McCl_2$? (Atomic weights: Mg 24; Cl 35.) To solve this problem all of the following calculations would be useful *except*
(4.10)

A. All of the following are essential.
B. $2 \times 35 + 24 = 94$.
C. $\frac{35 + 24}{94} = 57.5\%$. **D.** $\frac{24}{94} \times 100 = 25.6\%$.
E. $.256 \times 2000 = 512$.

232. The correct answer to the above problem is
(2.10)

A. 940 lbs. **B.** 575 lbs. **C.** 256 lbs.
D. 512 lbs.
E. some quantity differing from any of the above and by more than 100 pounds.

233. When an unknown gas is bubbled through clear lime water, $Ca(OH)_2$, a white precipitate forms. The gas can be assumed to be carbon dioxide providing
(4.10)

A. all of the following are true.
B. no other gas forms a white precipitate in lime water.
C. that the gas does not react chemically with the lime water.
D. no other substance gives a white precipitate with CO_2.
E. there is no marked change in the temperature of the lime water.

Items 234 - 247. Study the selection given below and the directions which follow it. Then answer the items, referring back to the selection as often as you wish. Your answers to some of the items, those to be marked *B* or *D*, will involve chemical information not given in the selection but which you should possess.

The present-day Bessemer converter used in the United States is a pear-shaped pot of wrought iron about ten feet in diameter and twenty feet in depth, lined to a thickness of two feet with a heat-resisting brick made up largely of sand, SiO_2, an acidic substance. Fifteen tons of a fiery broth of molten cast iron, whose chief impurities are carbon and silicon, are poured into the Bessemer converter from the blast furnace. Through this molten mass blasts of hot air are forced under high pressure through holes at the bottom of the converter. This blow lasts about ten minutes. The oxygen in the blasts of air oxidizes the iron it strikes, first forming ferrous oxide, which in turn reacts with the silicon impurity, forming silicon dioxide and iron thus:

$$Si + 2FeO \rightarrow SiO_2 + 2Fe.$$

This silicon dioxide is insoluble in the molten iron and accumulates as slag. As the blow continues, the carbon impurities begin to burn. A roaring boil then takes place in the converter; the carbon monoxide burns at the mouth of the converter; and countless flying sparks of metal and slag add to the spectacle. In a few minutes the carbon is gone; the flame flickers and contracts. This is the signal to stop the blast by turning the converter vessel over on its side. Inside the converter a seething mass of molten iron is covered with a thin layer of slag. The metal, however, contains some dissolved gases, and, if solidified at that point, would be spongy. So a predetermined amount of carbon and manganese is added in the form of iron alloys, such as ferro-manganese (containing about 70 per cent of Mn) or spiegeleisen (containing about 10 per cent of Mn). About fourteen pounds of manganese are used to every ton of steel produced. The manganese unites with any dissolved or combined oxygen and in addition strengthens the steel by its presence. The chemical reactions which take place in the converter when spiegeleisen is added are

$$Mn + O_2 \rightarrow MnO_2.$$
$$Mn + 2FeO \rightarrow MnO_2 + 2Fe.$$
$$3Fe + C \rightarrow Fe_3\,C.$$

The converter is then tipped completely over, and the liquid steel is poured into a waiting mold.—Adapted from Bernard Jaffe's *New World of Chemistry*, by permission of Silver Burdett Company.

After the number on the answer sheet corresponding to that of each statement blacken space

A. if the statement is true, and its truth is supported by information given in the selection.
B. if the statement is true, but its truth is *not* supported by information given in the selection.
C. if the statement is false, and its falsity is shown by information given in the selection.
D. if the statement is false, but its falsity is *not* shown by information given in the selection.

234. Acid forming elements, such as phosphorus and sulfur, if present in the iron, will react with the lining of the converter to form part of the slag.
(4.10)

235. Most of the carbon monoxide is oxidized to carbon dioxide inside the converter.
(4.10)

236. Although an excess of carbon is an impurity, it is desirable that at the end of the process some carbon be present in the steel produced.
(4.10)

237. Both manganese and silicon act as reducing agents.
(4.10)

238. Spiegeleisen contains no carbon.
(4.10)

239. The oxygen in the hot blast combines directly with the silicon to form silicon dioxide.
(4.10)

240. Carbon or carbon monoxide acts as a reducing agent in the presence of hot iron oxide.
(4.10)

241. The silicon dioxide in the slag results largely from oxidation of Si to SiO_2.
(4.10)

242. Most of the steel produced in the United States is produced in Bessemer converters.
(4.10)

243. Spiegeleisen probably contains more iron than ferromanganese.
(4.10)

244. Manganese has other functions than that of eliminating dissolved oxygen.
(4.10)

245. In addition to forming oxides, silicon and carbon have a number of other similar chemical properties.
(4.10)

246. Molten cast iron is molten pig iron.
(4.10)

247. Steel produced as described in the selection contains less than one per cent of manganese.
(4.10)

For items 248 - 255, after each item number on the answer sheet, blacken space

A. if the statement is true and its truth is supported by the reason given.
B. if the statement is true but its truth is not supported by the reason given.
C. if the statement is false.

248. Potassium reacts more vigorously than sodium, because its valence electron is closer to the nucleus of the atom.
(4.20)

249. Chlorine reacts more vigorously than iodine, because its atomic radius is smaller than that of iodine.
(4.20)

250. Non-metals lose electrons more readily than metals, because they have more electrons in their outermost shells.
(4.20)

251. Acetic acid is a weaker acid than hydrochloric acid, (4.20) because each molecule of acetic can release only one hydrogen ion.

252. When zinc reacts with hydrochloric acid, zinc atoms (4.20) become zinc ions. The hydrogen ions of the acid act as the oxidizing agent, because they gain electrons from the zinc atoms.

253. When hydrogen ions acquire electrons, the change is (4.20) reduction, because electrons have been gained.

254. Only an electric current can be used to reduce aluminum (4.20) to the metallic state, because no other reducing agent is sufficiently vigorous.

255. The gases of Group O of the periodic table do not react (4.20) chemically with other elements, because they do not gain or lose electrons under chemical conditions.

Items 256 - 260. The reaction between carbon dioxide (CO_2), water (H_2O), and calcium carbonate ($CaCO_3$) is reversible: $CaCO_3 + H_2O + CO_2 \rightleftarrows Ca(HCO_3)_2$. When water charged with carbon dioxide passes over or through limestone ($CaCO_3$), calcium ions (Ca^{++}) and bicarbonate ions (HCO_3^-) go into solution. When calcium bicarbonate solution is boiled or when the carbon dioxide pressure is reduced, carbon dioxide escapes from solution and calcium carbonate is reprecipitated. Items 256 - 260 are to be answered in accordance with the following key.

KEY

- **A.** The statement is true and this conclusion follows from the information given.
- **B.** The statement is true but this conclusion cannot be derived from the information given.
- **C.** The statement is false and this conclusion follows from the information given.
- **D.** The statement is false but this conclusion cannot be derived from the information given.

256. When ground water containing calcium bicarbonate in (4.20) solution seeps out of rocky ledges, deposits of calcareous tufa may be formed because of a reduction in the carbon dioxide pressure.

257. A solution containing calcium and bicarbonate ions is (4.20) stable at high temperature.

258. Water containing calcium ions is considered to be hard (4.20) water.

259. Sinkholes and caves are readily formed in regions where (4.20) the soil is underlain at moderate depth by limestone formations.

260. Most limestone formations in existence at the present (4.20) time were formed by precipitation of calcium carbonate from solutions of calcium bicarbonate.

25. *Oxidation and Reduction*

OXIDATION AND REDUCTION

1. Of the following, the most active reducing agent is
(1.10)

A. F. **B.** Na. **C.** K. **D.** Cl. **E.** C.

2. In a reaction involving oxidation-reduction
(1.10)

A. a change of valence from -2 to 0 is due to a gain of electrons.
B. the number of electrons gained equals the number lost.
C. the oxidizing agent is oxidized.
D. the reducing agent undergoes no chemical change.
E. the reducing agent gains electrons.

3. Potassium, when it combines with chlorine, is
(1.10)

A. a reducing agent and is itself reduced.
B. a reducing agent and is itself oxidized.
C. an oxidizing agent and is itself oxidized.
D. an oxidizing agent and is itself reduced.
E. sharing electrons regardless of oxidation-reduction.

4. Sodium, when it combines with chlorine, is
(1.10)

A. a reducing agent and decreases the valence of chlorine.
B. a reducing agent and increases the valence of chlorine.
C. an oxidizing agent and decreases the valence of chlorine.
D. an oxidizing agent and increases the valence of chlorine.
E. sharing electrons regardless of oxidation-reduction.

5. Chlorine is useful in purifying water because
(1.10)

A. its odor keeps bacteria away.
B. it precipitates poisonous material.
C. of its oxidizing properties.
D. of its neutralizing properties.
E. it readily escapes as a gas.

6. All of the following are reasons for the extensive use of
(1.10) iron except that

A. its ores are widely distributed.
B. it is easily extracted from its ores.
C. it has many useful physical properties.
D. it forms numerous alloys.
E. it combines readily with oxygen.

7. A product which is a good reducing agent may be ob-
(1.10) tained by

A. the electrolysis of water.
B. heating mercuric oxide.
C. burning carbon with a generous supply of oxygen.
D. heating potassium chlorate ($KClO_3$) with a suitable catalyst.
E. none of the above.

8. In the recovery of a metal from ore, suitable reducing
(1.10) agents are necessary. Which one of the following is *not* a reducing agent?

A. Carbon. **B.** Carbon dioxide. **C.** Hydrogen.
D. Coke. **E.** Electric current.

9. The reduction of aluminum ore differs from the reduc-
(1.10) tion of iron in that

A. aluminum ore is generally a sulfide rather than an oxide.
B. an electric current is needed for a source of electrons with aluminum.
C. carbon is indirectly used as the reducing agent for aluminum.
D. aluminum in ore is largely found in a free state.
E. the impurities furnish the fuel for the roasting process in the case of aluminum.

10. In the formation of NaCl, the sodium becomes an ion by
(1.10)

A. the reduction of sodium to produce a positive ion.
B. the oxidation of sodium to produce a positive ion.
C. the oxidation of sodium to produce a negative ion.
D. the reduction of sodium to produce a negative ion.
E. being made neutral.

Items 11 - 14. Indicate the most closely related word or phrase from the following key.

KEY

A. Gain of electrons. **B.** Loss of electrons.
C. Presence of C and H.
D. Number of outer electrons. **E.** Presence of H^+.

11. Valence. **12.** To be reduced.
(1.10) (1.10)

13. Hydrocarbon. **14.** To be oxidized.
(1.10) (1.10)

15. One of the following is *not* a reducing agent.
(1.10)

A. Hydrogen. **B.** Electric current. **C.** Chlorine.
D. Coke.

16. Bromide ion
(1.10)

A. is oxidized by iodine.
B. forms an insoluble salt with sodium ion.
C. is oxidized by chlorine.
D. is present in phosphorus tribromide.
E. is reduced by sulfuric acid when an attempt is made to prepare hydrogen bromide by the action of sulfuric acid on potassium bromide.

17. The oxidation state of chlorine in potassium chlorate is
(1.10)

A. -1. **B.** $+1$. **C.** $+3$. **D.** $+5$. **E.** $+7$.

18. An oxidizing agent is a substance that
(1.10)

A. takes electrons from other substances.
B. gives electrons to other substances.
C. takes protons from other substances.
D. gives protons to other substances.
E. in *all* cases gives oxygen to other substances.

19. Carbon dioxide
(1.10)

A. acts as an oxidizing agent on red hot coke.
B. may be made by dehydrating formic acid.
C. is heavier than hydrogen but lighter than oxygen.
D. removes protons from water in which it is dissolved.
E. is an important constituent of water gas.

20. (1.10) The Bunsen burner is effective for heating purposes because

A. the cracking of higher hydrocarbons is promoted.
B. the air is preheated.
C. the wire gauze prevents the ignition of gas outside the device.
D. through cooling of the gas at the center of the flame, cracking and consequent separation of particles of solid carbon are avoided.
E. the larger size of the flame produces a higher temperature in its hottest zone.

21. (1.10) Concerning flames,

A. *all* fuels burn with the production of flame.
B. a flame is a burning gas.
C. the hottest portion of the flame is the innermost part.
D. the reducing flame is the extreme tip.
E. flames containing solid carbon particles are most effective for heating purposes.

22. (1.10) The Goldschmidt process

A. often employs ferric oxide as the oxidizing agent.
B. has as its sole object the attainment of high temperature.
C. is a good example of an endothermic action.
D. is sometimes employed as a substitute for the action of thermit.
E. involves no change in the oxidation states of the elements taking part in the reaction.

23. (1.10) When iron rusts

A. the process is a simple union of iron and oxygen to form Fe_2O_3.
B. the greater the amount of the impurities that iron contains, in general the less apt it is to rust.
C. iron loses electrons at one point to form Fe^{++} ions, while water takes up electrons at another point to form OH^- ions.
D. pure iron never rusts, even if in contact with water.
E. the rust forms a protective coating over the metal.

24. (1.10) In copper metallurgy

A. the sulfide of copper is oxidized more easily than is the sulfide of iron.
B. silica combines readily with iron oxide, but not with copper oxide.
C. copper oxide requires long heating with carbon for its reduction to metallic copper.
D. copper sulfide ore is wetted preferentially by water, rather than by oil.
E. copper ore is refined electrolytically before it is smelted.

25. (1.10) In developing a photographic plate

A. sodium thiosulfate is used as a reducing agent.
B. the exposed plate is reduced most rapidly where the most light has been absorbed.
C. it is left in the developer until all of the silver bromide has been reduced.
D. no visible change takes place.
E. free bromine is liberated.

Items 26 - 27 deleted.

28. (1.10) Concentrated sulfuric acid

A. is a liquid the vapor pressure of which, at room temperature, is greater than that of water.
B. is an electrovalent compound.
C. when hot, is capable of being reduced to SO_2.
D. gives off choking fumes at room temperature.
E. has a lower specific gravity than either concentrated hydrochloric or nitric acids.

29. (1.10) Which is most nearly correct?

A. Most metals occur in the form of the free element in nature.
B. One type of iron ore is Fe_2O_3 and iron is obtained by reducing with carbon in the form of coke.
C. Another metal, sodium, occurs in sodium chloride and is obtained by the reduction of the sodium with carbon.
D. More active metals are more easily converted to free metals than the less active ones.
E. Steel is the purest form of iron.

30. (1.25) Fluorine is produced by

A. the action of powerful chemical oxidizing agents on fluorides.
B. the action of chlorine on potassium fluoride.
C. the decomposition of fluorspar at high temperatures.
D. the reduction of the fluoride ion.
E. the electrolysis of KHF_2.

31. (1.25) Chlorine may be made by

A. the oxidation of the chloride ion.
B. the reduction of chlorine atoms.
C. the action of sulfuric acid on chlorides.
D. heating potassium chlorate with manganese dioxide.
E. the action of bromine upon chlorides.

32. (1.30) All of these statements concerning oxidation are correct *except* that

A. the oxidation of a metal produces an increase in weight.
B. the oxidizing agent increases the valence of something else.
C. oxidation cannot take place without reduction.
D. oxygen is necessary for oxidation to take place.
E. the oxidizing agent takes electrons away from something else.

33. (1.30) In a chemical reaction, the valence of the element phosphorus was changed from 0 to +5. All of the following statements are true except the one stating that phosphorus

A. reduced something else. **B.** was oxidized.
C. gained protons. **D.** lost electrons.
E. acted as a metal.

34. (1.30) Which of the following characteristics would yield the most evidence toward determining whether an unknown gas was a good reducing agent?

A. The gas has a very low density.
B. The gas has a high molecular weight.
C. The gas is liberated from certain salts of all metals.
D. The gas burns in oxygen to form water.
E. The gas forms an acid solution in water.

For item 35 select from the key the most appropriate response.

KEY

A. The first part of the statement is true, and its truth is supported by the reason given in the statement.
B. The first part is true, but its truth is *not* supported by the reason given.
C. The first part of the statement is false.

35. (1.30) Metals are oxidizing agents because they furnish electrons in chemical reactions.

36. (1.30) In the family comprising the best oxidizing agents, oxidizing power

A. increases as the valence increases.
B. is greatest with oxygen.
C. increases as the atomic weight increases.
D. increases as the substance increases in metallic properties.
E. increases as the atomic number decreases.

37. (1.30) The halogen elements

A. are the only non-metals which form anions.
B. are readily oxidized to form univalent anions.
C. form molecules the stabilities of which increase steadily with increased atomic weights of the elements.
D. form covalent compounds with nearly all other elements.
E. show a tendency to take on electrons which decreases as the atomic radius increases.

38. (1.30) When metallic zinc is placed in an aqueous solution of zinc ions

A. no effect is produced.
B. the metal dissolves until the concentration of its ions in the solution has reached the equilibrium concentration.
C. zinc hydroxide is formed and hydrogen is given off.
D. metallic zinc is deposited on the bar.
E. the metal dissolves, but the action is almost at once brought to a standstill as a result of the accumulation of electrons on the bar.

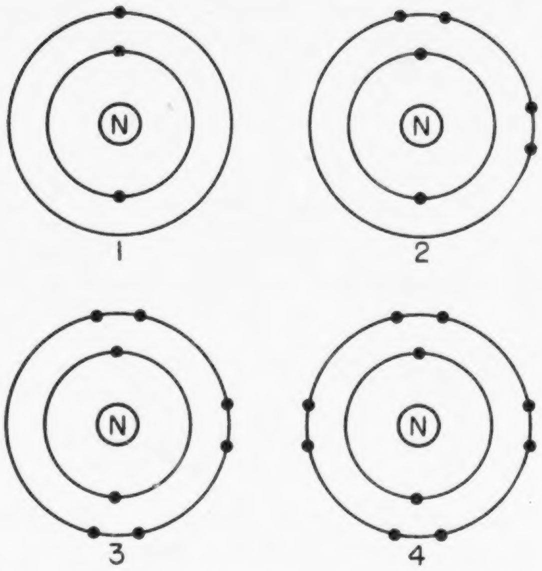
39. (1.30) With reference to oxidation and reduction

A. zinc is a better oxidizing agent than copper because it is above the latter element in the activity series.
B. the fluoride ion is a powerful reducing agent.
C. oxidation always takes place at the anode in electrolysis.
D. in the union of copper with chlorine, the latter element is oxidized.
E. the oxidation state of sulfur is +6 in all its compounds containing oxygen.

40. (1.30) Which of the following statements is *not* true?

A. An atom of the element oxygen has 6 electrons in the outermost electron shell or level.
B. Oxygen is a very electronegative element.
C. A chemical process involving oxidation always requires the presence of oxygen.
D. Oxygen combines with nearly all of the other elements except of course the inert gases.
E. Bonds between oxygen and other elements are fairly weak in general making oxygen compounds fairly unstable.

Items 41 - 44 refer to the following diagram.



The diagram symbolizes the electron configurations of the atoms of four different elements. Indicate which configuration would probably represent the element described in the statement. If none applies, mark space 5.

41. (2.10) Oxidizes other substances readily.

42. (2.10) Chemically inactive.

43. (2.10) A very good reducing agent.

44. (2.10) Shows a great tendency to form compounds by sharing electrons.

45. (2.10) An element which is a good oxidizing agent

A. is a non-metal and is itself reduced.
B. is a non-metal and is itself oxidized.
C. is a metal and is itself oxidized.
D. is a metal and is itself reduced.
E. is a metal but is not itself oxidized or reduced.

46. (2.10) An oxidizing agent is a substance that always

A. contains oxygen.
B. readily gives up one or more electrons.
C. contains an element the valence of which readily increases.
D. contains an element the valence of which readily decreases.
E. will burn.

47. (2.10) When a storage cell normally discharges, the anode changes from PbO_2 to $PbSO_4$. During this change the

A. specific gravity of the electrolyte increases.
B. PbO_2 is reduced.
C. voltage drops from two volts to zero.
D. Pb increases in valence.
E. anode becomes negatively charged.

48. (2.10) The equation representing a reduction is

A. $SiO_2 + 4HF \rightarrow SiF_4 + 2H_2O$.
B. $3Cu + 8HNO_3 \rightarrow cCu(NO_3)_2 + 4H_2O + 2NO$.
C. $NaCl + H_2SO_4 \rightarrow HCl + NaHSO_4$.
D. $NaNO_3 + KCl \rightarrow NaCl + KNO_3$.
E. $Na_2SO_3 + 2HCl \rightarrow 2NaCl + H_2O + SO_2$.

796B

Items 49 - 52. The charge of a blast furnace includes iron ore in the form of Fe_2O_3 and C in the form of coke. The chief end products are Fe and CO_2.

49. (2.10) The substance that loses electrons during the process.

50. (2.10) The substance that gains electrons during the process.

51. (2.10) The reducing agent.

52. (2.10) The chief material in the pig iron that is formed.

A. Fe^{+++}.
B. $O^{=}$.
C. C.
D. C^{++}.
E. Fe.

53. (2.10) An increase in valence of one atom during a reaction is called

A. neutralization. **B.** oxidation. **C.** ionization.
D. polymerization. **E.** hydration.

54. (2.10) The valence of a substance designates its

A. state of oxidation. **B.** atomic number.
C. atomic weight. **D.** nuclear charge.
E. radioactive properties.

55. (2.10) The oxidation state of chlorine in potassium chlorate is

A. −1. **B.** +1. **C.** +3. **D.** +5. **E.** +7.

56. (2.20) In the equation for the manufacture of water gas, $H_2O + C \rightarrow CO + H_2$, carbon is

A. reduced. **B.** a catalyst. **C.** a base.
D. an oxidizing agent. **E.** a reducing agent.

57. (2.20) In the reaction, $Sn + 4HNO_3 \rightarrow SnO_2 + 4NO_2 + 2H_2O$, each atom of tin (Sn)

A. gains 2 electrons. **B.** gains 4 electrons.
C. loses 2 electrons. **D.** loses 4 electrons.
E. none of these.

58. (2.20) Gold is below hydrogen, and sodium is above hydrogen in the electromotive series. This indicates that

A. sodium is heavier than gold.
B. gold is relatively soft.
C. sodium has a complete outer ring of electrons.
D. gold will not "rust."
E. sodium is an integral part of acid salts.

59. (2.20) When a large jar is placed over a lighted candle, the candle burns for a few minutes and then goes out. On the basis of the Phlogiston Theory, this would suggest that

A. all the phlogiston in the air was consumed by the burning candle.
B. the air in the jar became saturated with phlogiston.
C. the air in the jar became too hot to receive phlogiston.
D. carbon dioxide produced by the burning candle extinguished the flame.
E. this is a phenomenon that could not be explained by the Phlogiston Theory.

60. (2.20) In the equation $Cu^{++}O^{--} + H^{\circ}_2 \rightarrow Cu^{\circ} + H_2^{(+)}O^{--}$ where the signs represent the electrical charge on the atom, which one of the following is the product of reduction?

A. Cu°. **B.** Cu^{++}. **C.** $H_2^{(+)}$. **D.** H°_2.
E. O^{--}.

61. (3.00) When heated, magnesium reacts with a limited supply of air to form a solid product. If this solid product is treated with water, magnesium hydroxide, ($Mg(OH)_2$), and ammonia, (NH_3), are formed. From this information, the solid product can be identified as most probably being

A. Mg_2O. **B.** MgO. **C.** MgO_2. **D.** MgN.
E. Mg_3N_2.

62. (3.00) The combustion of a mole of heptane (C_7H_{16}) needs

A. 224 liters of oxygen, measured at S.T.P.
B. 44.8 liters of oxygen, measured at S.T.P.
C. 268.8 liters of oxygen, measured at S.T.P.
D. 246.4 liters of oxygen, measured at S.T.P.
E. none of these numbers.

63. (3.00) If a mole of glucose, $C_6H_{12}O_6$, is completely oxidized in the body to carbon dioxide, the volume of carbon dioxide produced at S.T.P. will be

A. 44.8 liters. **B.** 22.4 liters. **C.** 110 liters.
D. 134.4 liters. **E.** none of these numbers.

Items 64 - 67 are based on the following observations which have been made on four metals, X, Y, Z, and W.

A. Metal X dissolved in hydrochloric acid.
B. When metal Y is heated with the oxide of metal X, metal X is liberated and the oxide of metal Y is formed with the evolution of a great deal of heat.
C. Metal Z does not dissolve in hydrochloric acid.
D. Metal W is displaced by metal X in a solution of WCl_2.

64. (3.00) Which is the more active, metal X or metal Y?

A. Metal X. **B.** Metal Y.
C. Both are equally active.
D. It is not possible to tell.

65. (3.00) Which is the better reducing agent, metal Z or hydrogen?

A. Metal Z. **B.** Hydrogen.
C. It is not possible to tell.

66. (3.00) Which is the more active, metal Y or metal W?

A. Metal Y. **B.** Metal W.
C. It is impossible to tell.

67. (3.00) Which is the better reducing agent, metal Z or metal W?

A. Metal Z. **B.** Metal W.
C. It is impossible to tell.

Items 68 - 72 contain pairs of statements which are either consistent (in agreement) or inconsistent with each other *and* either one of the statements may be true or false. For each item select from the key the correct response.

KEY

A. I and II are consistent; and both true.
B. I and II are consistent; but both false.
C. I and II are inconsistent; I true, II false.
D. I and II are inconsistent; I false, II true.

68. (4.20) I. Endothermic reactions proceed spontaneously.
II. Energy is absorbed in endothermic reactions.

69. I. If a metal is oxidized its valence is lowered.
(4.20) II. An oxidizing agent lends electrons to the metal it oxidizes.

70. I. Astigmatism makes round objects appear slightly oval.
(4.20) II. In astigmatism the eye lens is more convex in one plane than another.

71. I. Power in science means the time rate of working.
(4.20) II. Power equals work times time.

72. I. $HC_2H_3O_2$ should be classed as an acid.
(4.20) II. All acids are capable of furnishing hydrogen ions.

Items 73 and 74 refer to the following equation where the exponents show the electrical state.

$$\overset{0}{Zn} + 2\overset{+1\ -1}{HBr} \rightarrow \overset{+2\ (-1)_2}{ZnBr_2} + \overset{0}{H_2}$$

For each item select from the key the most appropriate response.

KEY

- **A.** Statement true–reason supports it.
- **B.** Statement true–reason false.
- **C.** Statement false.

73. (4.20) Br was reduced because its valence increased in the reaction.

74. (4.20) Zn was oxidized in the reaction because it lost electrons.

75. (4.20) According to the Phlogiston Theory, when wood burns its ashes weigh less than the original wood, and the decrease in weight may be reasonably interpreted as the weight of the Phlogiston which has escaped. When a metal is heated, however, the resulting powder weighs more than the original metal. In terms of the Phlogiston Theory, this would seem to indicate that

- **A.** Phlogiston could also have a negative weight, so that its escape would therefore make a substance heavier.
- **B.** burning is a different chemical process than that which is involved in the heating of a metal until it changes into a powder.
- **C.** while burning liberates Phlogiston, heating a metal attracts Phlogiston.
- **D.** in burning a substance some of the Phlogiston which is present is consumed as the product of combustion, while in heating a metal Phlogiston combines with the metal to form scale.
- **E.** more than one of these could account for the results.

76. (4.20) We no longer accept the Phlogiston Hypothesis of combustion because prediction does *not* agree with observation in one of the following instances.

- **A.** Combustion of a substance results in a new substance being formed.
- **B.** New properties may appear when a substance is burned.
- **C.** When a metal is burned phlogiston is expelled from it, resulting in a loss of weight.
- **D.** Metals can be recovered from their ores by heating with charcoal.
- **E.** A substance heated in a limited amount of air is only partially burned.

Items 77 - 82. Consider the following theories in explanation of the burning of material in air:

Theory X. During combustion, a substance escapes from the burning material into the surrounding air. The capacity of air to take up this escaping substance is limited.

Theory Y. During combustion, the burning material unites with a certain component of the air.

After the number on the answer sheet corresponding to each of the following items, blacken space

- **A.** if the item supports Theory X rather than Theory Y.
- **B.** if the item supports Theory Y rather than Theory X.
- **C.** if the item supports both theories equally well.
- **D.** if the item, taken by itself, does not support either theory.

Assume you know no facts other than those given in the numbered items below.

77. (4.20) A candle in a closed jar stops burning before the candle is completely burned.

78. (4.20) Air contains approximately 20 per cent oxygen.

79. (4.20) The product formed by burning iron in air weighs more than the original iron.

80. (4.20) A candle burns more brightly in a breeze than in still air.

81. (4.20) Illuminating gas burns more brightly in chlorine than in air.

82. (4.20) Some products of burning, when heated in air which no longer supports burning, lose weight and restore the original properties of the air.

26. *Acids, Bases, Salts, and Ionization*

ACIDS, BASES, SALTS, AND IONIZATION

1. (1.10) When oxides of metals are dissolved in water, the resulting solution

A. is basic. **B.** is capable of furnishing H^+ ions.
C. turns blue litmus red. **D.** is strongly acidic.
E. is neutral.

2. (1.10) A metallic oxide dissolved in water produces a solution that

A. is capable of furnishing OH ions.
B. is capable of furnishing H ions.
C. fails to conduct an electric current.
D. exhibits the properties of a non-polar compound.
E. is neutral.

3. (1.10) Selenium (Se) is a non-metallic element. If it is caused to combine with oxygen and then water, the result should be

A. a salt. **B.** an acid. **C.** an hydroxide.
D. a metal. **E.** a chloride.

4. (1.10) When non-metallic oxides like SO_2 are dissolved in water

A. the solution is acidic. **B.** the solution is basic.
C. the solution may either be acidic or basic depending upon which non-metallic oxide is broken.
D. the bond of the non-metal with oxygen is broken.
E. no chemical change occurs.

5. (1.10) When non-metallic oxides like CO_2 are dissolved in water

A. H^+ is liberated. **B.** the solution is basic.
C. OH^- is formed by dissociation.
D. the bond of the non-metal with oxygen is broken.
E. no chemical change occurs.

6. (1.10) The neutralization of an acid by a base always produces

A. soluble products. **B.** a precipitate.
C. a gas. **D.** sodium chloride. **E.** water.

7. (1.10) An acid or base is said to be active or strong if it

A. is highly concentrated.
B. is in a state of equilibrium.
C. attacks steel rapidly. **D.** is highly dissociated.
E. is highly hydrated.

8. (1.10) The degree of ionization of a solution refers to

A. the number of molecules in the solution.
B. the ratio of molecules dissociated to those undissociated.
C. the ratio of molecules dissociated to the total number of molecules.
D. the quantity of electricity produced.
E. the quantity of free electrons produced.

9. (1.10) All reactions between acids, bases, and salts in water occur between

A. molecules. **B.** atoms. **C.** ions. **D.** catalysts.
E. protons.

10. (1.10) A good chemical test for metals is that

A. they always displace hydrogen from acids.
B. a pure metal turns litmus paper blue.
C. they are all heavier than water.
D. they are never malleable and ductile.
E. their oxides tend to form bases when combined with water.

11. (1.10) Electrolytes are compounds which

A. are covalent. **B.** are un-ionized.
C. are non-polar. **D.** result from transfer of electrons.
E. result from sharing of electrons.

12. (1.10) In *all* cases where solutions of acids and bases react

A. water is formed. **B.** a neutral salt is formed.
C. one product escapes as a gas.
D. a basic salt is formed. **E.** an acid salt is formed.

13. (1.10) $NaHCO_3$ is

A. an acid salt. **B.** a basic salt. **C.** a neutral salt.
D. classified in some other way.

14. (1.10) Carbonic acid attacks limestone and changes it into a new substance called

A. sodium carbonate. **B.** sodium bicarbonate.
C. calcium carbonate. **D.** calcium bicarbonate.
E. magnesium carbonate.

15. (1.10) One would expect a *non*-dissociated compound to be

A. bivalent. **B.** a polar compound.
C. a compound resulting from electron exchange.
D. in an ionized state. **E.** none of the above.

16. (1.10) If atoms are deprived of electrons, there are formed

A. ions. **B.** neutrons. **C.** deuterons.
D. beta particles. **E.** negatrons.

17. (1.10) Which of the following is a salt?

A. KNO_3. **B.** $HC_2H_3O_2$. **C.** $Ca(OH)_2$.
D. $H_2C_2O_4$. **E.** NH_4OH.

18. (1.10) Reaction between an acid and a base may produce any one of the following *except*

A. a hydrocarbon. **B.** a salt. **C.** an acid salt.
D. a carbonate. **E.** a basic salt.

19. (1.10) When salts ionize in solution, they split into positive and negative ions. Which one of the following forms a negative ion?

A. Hydrogen. **B.** Hydroxide. **C.** Ammonium.
D. Calcium. **E.** Sodium.

20. (1.10) The following represents two correctly balanced equations for the reaction of sodium chloride and sulfuric acid.

(a) $2NaCl + H_2SO_4 \rightarrow 2HCl + Na_2SO_4$
(b) $NaCl + H_2SO_4 \rightarrow HCl + NaHSO_4$

$NaHSO_4$ is obtained in equation (b) rather than Na_2SO_4 because

A. an excess of acid was used in equation (b).
B. sodium has two valences.
C. more heat was applied in (b) which drove off some of the reactants.
D. some equations may be balanced in several ways.
E. Cl exists as several isotopes.

Items 21 - 29. After each item number on the answer sheet, blacken space

A. if the item is generally true of acids.
B. if the item is generally true of bases.
C. if the item is generally true of salts.
D. if the item is generally true of all of the above.
E. if the item is generally true of none of the above.

21. Furnish an excess of H^+ ions in water solution.
(1.10)

22. Are not usually classified as weak or strong.
(1.10)

23. Will conduct an electrical current when dissolved in
(1.10) water.

24. Are always covalent compounds when dissolved in water.
(1.10)

25. A water solution will turn litmus blue.
(1.10)

26. May be formed during the process of neutralization.
(1.10)

27. $AgCl$ is an example.
(1.10)

28. Vinegar is used because it contains this type of com-
(1.10) pound.

29. Ordinary lye would be classified under this heading.
(1.10)

30. Electrolysis is the
(1.10)

A. production of electric current by chemical reaction.
B. production of ions by water.
C. decomposition of an ionic compound by electric current.
D. removal of hair by ionic needles.

31. The process in which hydrogen and hydroxyl ions in a
(1.10) solution unite to form water, and the other ions unite to form a salt is termed

A. hydrogenation. **B.** ionization. **C.** neutralization.
D. oxidation. **E.** hydrolysis.

32. The process of removing all of the hydrogen ions from
(1.10) a solution by adding an equal number of hydroxyl ions is called

A. ionization. **B.** hydrolysis. **C.** electrolysis.
D. precipitation. **E.** neutralization.

33. The combination of the hydroxyl ion of a base and the
(1.10) hydrogen ion of an acid is called

A. hydrolysis. **B.** hydration. **C.** neutralization.
D. titration. **E.** hydrogenation.

For each of the practices or observations stated in items 34 - 49 indicate from the following list the kind of change involved.

A. Oxidation-reduction. **B.** Ionization.
C. Neutralization. **D.** Physical change.

34. Use of baking soda in leavening dough.
(1.10)

35. Deterioration of rubber tires in storage.
(1.10)

36. Use of chlorine in purifying water.
(1.10)

37. Using ground limestone on certain kinds of soil.
(1.10)

38. Beating an egg until it becomes light and foamy.
(1.10)

39. The sour taste of vinegar.
(1.10)

40. Production of heat in a gas range.
(1.10)

41. Production of heat in an electric range.
(1.10)

42. The sour taste of old milk.
(1.10)

43. Use of soda to relieve distress after over-eating.
(1.10)

44. Discoloration of fruit which is left in open air.
(1.10)

45. Death or injury resulting from snapping an electric
(1.10) light switch while standing in a tub of water.

46. Whipping cream with an electric beater.
(1.10)

47. Making maple sugar from sap.
(1.10)

48. Injury to skin caused by strong soaps and washing
(1.10) powders.

49. Use of vinegar in removing hard water stains from
(1.10) glassware.

Items 50 - 56 are concerned with statements and equations in chemistry. Select from the key the most appropriate response for each item.

KEY

A. Bases. **B.** Acids. **C.** Salts. **D.** Acid salts.
E. Basic salts.

50. The positive part of the base (metallic) and the nega-
(1.10) tive part of the acid (usually non-metallic) form a new compound.

51. Soapy taste.
(1.10)

52. Ability to release hydrogen gas when in contact with
(1.10) certain metals.

53. The solution contains many hydroxyl ions.
(1.10)

54. $HC_2H_3O_2$.
(1.10)

55. $Cu_2(OH)_2CO_3$ (malachite).
(1.10)

56. Excess of acid present during the formation of a new
(1.10) compound. The possibility of two different compounds being found depending on the amount of acid present.

Items 57 - 64 involve chemical substances. Select from the key the most closely related term for each item.

KEY

A. Non-electrolyte. **B.** Electrolyte. **C.** Hydrate.
D. Ion. **E.** None of these.

57. An atom carrying an electric charge.
(1.10)

58. A solution of sugar in water.
(1.10)

59. Compounds made by borrowing or lending electrons
(1.10) which in solution form conductors.

60. An unstable solution in which the solvent contains more
(1.10) solute than it can hold under normal conditions.

61. $CaSO_4 \cdot 2H_2O$.
(1.10)

62. NaCl.
(1.10)

63. A salt combining with a definite amount of water dur-
(1.10) ing crystallization.

64. H^+.
(1.10)

65. A saturated solution
(1.10)

A. is one that contains all the solute it can
B. is one having the composition indicated by any point in the area below and to the right of the solubility curve.
C. always boils at 100.51°C.
D. is one in which (in the presence of undissolved solute) the processes of solution and deposition are going on at equal rates.
E. is in an unstable condition and is thus likely at the slightest disturbance to relapse to an unsaturated solution.

66. An acid
(1.10)

A. is a substance which, when dissolved in the proper solvent, ionizes to produce hydrogen (H^+) ions.
B. is a substance which, under proper conditions, gives up protons.
C. is an electrovalent hydrogen compound.
D. produces an aqueous solution with a pH larger than 7.
E. is any compound containing hydrogen.

67. An indicator is a substance
(1.10)

A. which always changes color when the solution passes through that hydronium ion concentration at which the pH is 7.
B. in which the positive and negative ions have a different color.
C. which, under no conditions, is ever colorless.
D. which is used to detect whether the solution contains an excess of positive or of negative ions.
E. which changes color when passing through a definite pH range, characteristic of that indicator.

68. In an aqueous solution of Na_2CO_3
(1.10)

A. the pH is less than 7. **B.** the reaction is neutral
C. the reaction is alkaline because the $CO_3^{=}$ ion is a strong base.
D. the reaction is alkaline because of the common ion effect.
E. the Na_2CO_3 is completely decomposed at the time the solution is made.

69. Of the compounds of sulfur
(1.10)

A. sulfurous acid can give off but a single proton per molecule.
B. the first ionization constant of H_2S is a large number.
C. the pH of sulfuric acid in dilute solutions is a number much less than 7.
D. when prepared in the laboratory, sulfur dioxide is usually collected over water.
E. hydrogen sulfide is a good oxidizing agent.

70. Concentrated sulfuric acid
(1.10)

A. is a liquid the vapor pressure of which, at room temperature, is greater than that of water.
B. is an electrovalent compound.
C. when hot, is capable of being reduced to SO_2.
D. gives off choking fumes at room temperature.
E. has a lower specific gravity than either concentrated hydrochloric or nitric acids.

71. An aqueous solution of ammonia
(1.10)

A. has a pH of less than 7 because the ammonia molecule picks up protons from the water.
B. provides a low concentration of hydroxyl ions and is therefore useful for cleaning purposes.
C. is almost completely ionized into ammonium and hydroxyl ions.
D. has its hydroxyl ion concentration increased by the addition of ammonium chloride.
E. is the only form of nitrogen that plants can assimilate.

72. Orthophosphoric acid
(1.10)

A. forms three different sodium salts.
B. has the formula HPO_3. **C.** is diprotic.
D. gives off three protons in succession with about equal ease.
E. can be driven off in vapor form by treating a phosphate with sulfuric acid.

73. Cupric ions
(1.10)

A. are hydrated in aqueous solution.
B. in anhydrous copper sulfate are blue.
C. produce an alkaline reaction in aqueous solution.
D. take on electrons from metallic silver to form metallic copper.
E. are formed by the action of acids on metallic copper, with the release of hydrogen.

74. Concerning zinc
(1.10)

A. the metal is usually protected from the action of atmospheric oxygen by being galvanized.
B. the hydroxide may be made to react as an acid.
C. the hydroxide does not neutralize hydrochloric acid.
D. the oxide is an excellent abrasive.
E. the element never enters into the formation of complex ions.

75. An acid
(1,10)

A. is an electrovalent hydrogen compound.
B. is a covalent compound which gives hydrogen ions when dissolved in non-polar solvents.
C. produces aqueous solutions whose pH is greater than 7.
D. is always a neutral molecule.
E. has a tendency to give up protons to bases.

76. The acetate ion
(1.10)

A. is a triprotic acid because it contains three hydrogen atoms.
B. is an exceptionally weak base because it shows very little tendency to pick up protons.

C. is a strong acid because it takes up protons from hydronium ions readily.
D. is neither an acid nor a base.
E. is a moderately strong base because it readily picks up protons from hydronium ions to form acetic acid.

Item 77 deleted.

78. (1.10) What is the pH of a neutral solution?

A. 5. **B.** 7. **C.** 8. **D.** 10. **E.** 14.

79. (1.10) Which of the following is *not* true?

A. Some metals react with water to give bases.
B. Some metal oxides react with water to give bases.
C. Some metal oxides react with water to give acids.
D. Some non-metal oxides react with water to give acids.
E. Most non-metal oxides react with water to give bases.

80. (1.10) Which of the following is *not* true?

A. The pH is a measure of hydronium ion concentration.
B. A solution of pH 10 is basic.
C. A solution of pH 8 is acidic.
D. The hydroxide ion concentration multiplied by the hydronium ion concentration is equal to a constant number.
E. The hydronium ion concentration is equal to the hydroxide ion in pure water.

81. (1.10) If we had some hydrogen chloride (HCl) dissolved in water (hydrogen chloride is a strong acid) and we placed two platinum wires in the water, one charged negatively and the other positively, which of the following would be correct?

A. Nothing would happen.
B. Hydrogen gas would be given off at the negative wire.
C. Chlorine gas would be given off at the negative wire.
D. Both hydrogen and chlorine gases would be given off at the negatively charged wire.
E. Nothing would be expected to happen at the negatively charged wire.

82. (1.10) Concerning nitric acid

A. the nitrogen in the compound has the same oxidation state that it has in ammonia.
B. the concentrated laboratory reagent has no odor.
C. it is not possible to obtain 100% acid by distillation of an aqueous solution of the compound.
D. hydrogen is formed by the action of the acid on copper.
E. at room temperature the vapor pressure of the pure acid is less than that of concentrated H_2SO_4.

83. (1.24) A substance is an acid if it

A. turns phenolphthalein red.
B. dissociates to give the hydrogen ion.
C. turns litmus blue. **D.** will yield the OH ion.
E. always forms an acid salt.

84. (1.24) A solution is said to be basic if it

A. contains H+ ions. **B.** tastes sour.
C. turns litmus red. **D.** contains free protons.
E. contains hydroxyl ions.

85. (1.24) A certain solution turns blue litmus red, reacts with magnesium with slow evolution of gas, does not react with silver nitrate, and is a poor conductor of an electric current. The solution may contain

A. hydrochloric acid. **B.** ethyl alcohol.
C. sodium hydroxide. **D.** copper acetate.
E. acetic acid.

86. (1.24) A certain compound is a very poor conductor of electricity but can dissolve many other substances forming solutions which conduct electricity well. Its pH is 7 and it is formed when a base reacts with an acid. It is

A. acetic acid. **B.** sodium chloride. **C.** alcohol.
D. water. **E.** benzene.

87. (1.24) An unknown gas dissolves readily in water. The solution turns red litmus blue. The gas reacts with hydrogen chloride gas, forming a white fume. The unknown gas is

A. nitric oxide. **B.** ammonia. **C.** hydrogen sulfide.
D. carbon monoxide. **E.** sulfur dioxide.

88. (1.24) It is believed that pure acids (not dissolved in water) are *not* ionic compounds because

A. they do not give an excessive depression of the freezing point of water when dissolved in water.
B. in the liquid state, they are poor conductors of electricity.
C. they do not neutralize bases.
D. the statement is not true; pure acids *are* ionic compounds.

89. (1.24) All of the following are characteristic of a base *except*

A. it contains hydroxyl ions. **B.** it tastes sour.
C. it turns phenolphthalein blue.
D. it can be prepared by dissolving oxides of metals in water.
E. it furnishes negative ions.

90. (1.24) A certain compound is a very poor conductor of electricity, but can dissolve many other substances forming solutions which conduct electricity well. It is formed when a base reacts with an acid. It is

A. water. **B.** alcohol. **C.** acetone.
D. sodium chloride. **E.** acetic acid.

91. (1.25) To test whether an unknown compound is formed by sharing electrons or by electron transfer, the best procedure would be to

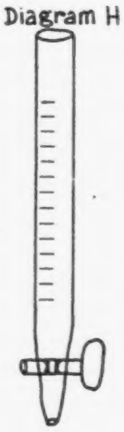
A. find out its percentage composition.
B. test its combustibility.
C. determine whether the compound has an electric charge.
D. test the solubility of the substance.
E. test the electrical conductivity of its water solution.

92. (1.25) Whether or not a solute dissociates upon solution may be determined by

A. noting the physical appearance of the solution.
B. filtering the solution.
C. passing an electric current through the solution.
D. noting the evolution of heat during solution.
E. observing a chemical change while the solute is dissolving.

Item 93 refers to Diagram H.

Diagram H



93. (1.25) A chemist would be most likely to use the set-up of apparatus indicated in Diagram H in the laboratory determination of

A. the volumetric composition of water.
B. the law of combining volumes.
C. the acidity of vinegar.
D. the products of the electrolysis of a salt solution.
E. the percentage of water in a hydrate.

94. (1.25) In the electrolysis of an aqueous solution of sodium chloride

A. an asbestos diaphragm is used to reduce heat losses.
B. equal volumes of hydrogen and chlorine are evolved at cathode and anode respectively.
C. a very pure solution of sodium hydroxide is produced.
D. hydrogen appears at the cathode because the sodium discharged there rapidly reacts with water to liberate hydrogen, especially if the electrolyte is hot.
E. the anode is usually made of zinc.

95. (1.25) In the contact sulfuric acid process

A. oxides of nitrogen are used as a catalyst.
B. very high temperatures are required.
C. the reaction goes on best in aqueous solution.
D. either platinum or compounds of vanadium may be used as catalysts.
E. the process of dissolving SO_3 in water offers no practical difficulties.

96. (1.25) Hydrogen sulfide may best be prepared in the laboratory by the action of

A. hydrochloric acid on copper sulfide.
B. hydrogen on iron sulfide. **C.** an acid on a sulfite.
D. hydrogen on sulfur.
E. hydrochloric acid on iron sulfide.

Items 97 - 105. After each item number on the answer sheet, blacken space

A. if the item is true only of strong acids.
B. if the item is true only of weak acids.
C. if the item is true of *both* strong and weak acids.
D. if the item is true only of bases.
E. if the item is true only of salts.

97. (1.30) Acetic acid is an example.

98. (1.30) In solution many of them have no effect on indicators such as litmus.

99. (1.30) One of the ions formed is a proton, or hydrogen ion.

100. (1.30) Ammonium hydroxide is an example.

101. (1.30) All of them are completely ionized in water solutions and turn blue litmus red.

102. (1.30) Yield OH^-, or hydroxyl ions, in solution.

103. (1.30) Sulfuric acid is an example.

104. (1.30) Best illustrates that, in solid form, positive and negative ions form a lattice rather than molecules of a compound.

105. (1.30) Sodium hydroxide is an example.

106. (1.30) For the equation $Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O$, which one of these is true?

A. The reaction will reach a state of equilibrium rather than completion.
B. The reaction will *not* reach completion because ions of a product are removed by formation of undissociated water molecules.
C. Completion is achieved because one of the products leaves as a gas.
D. The reactants will not form the desired products.
E. The reaction will be completed because a precipitate is formed.

107. (1.30) When an electric current is passed through a solution of sodium chloride

A. chloride ions travel toward the cathode or negative pole.
B. hydrogen ions gain electrons at the negative pole.
C. sodium ions gain and hold electrons at the negative pole.
D. chloride ions form chlorine gas on gain of electrons.
E. the solution eventually becomes acid.

108. (1.30) Ionic compounds differ from covalent compounds in that ionic compounds

A. usually form well defined crystals, covalent usually do not.
B. are all soluble in water, covalent are all insoluble.
C. never contain carbon, covalent always contain carbon.
D. are generally less volatile than covalent compounds.
E. none of the above.

109. (1.30) The degree of ionization of a solution refers to

A. the temperature of the solution.
B. the quantity of solution.
C. the number of molecules dissociated.
D. the quantity of electricity produced.
E. the quantity of free electrons.

110. (1.30) Copper ions could be removed from a copper sulfate solution by

A. adding electrons. **B.** adding protons.
C. filtration. **D.** centrifuging. **E.** distillation.

For items 111 - 114 select from the key the most appropriate response.

KEY

A. The second cannot occur unless the first has occurred or is occurring.
B. The first usually but not necessarily occurred before the second.
C. The second usually but not necessarily occurred before the first.
D. There is no relationship between the occurrence of the first and the second.

111. (1.30) Oxidation–Spontaneous combustion.

112. (1.30) Solution in water–Dissociation of ions.

113. (1.30) Gaseous ions–Discharge of an electroscope.

114. (1.30) Rubbing with silk or fur–Magnetization.

115. (1.30) Water, HOH, is neither acid nor basic in reaction because it

A. furnishes the hydrogen ion.
B. is formed by electron exchange.
C. furnishes only negligible amounts of hydrogen and hydroxyl ions and these in equal numbers.

116. (1.30) A condition which is necessary in order that a water solution conduct an electric current is that

A. the substance be placed in the water as the electrolyte must ionize.
B. the substance be placed in the water as the electrolyte must be a compound in which all composing elements are non-metals.
C. the compound in solution must be one formed by sharing electrons.
D. a chemical change must not take place during the process of conduction.
E. hydration must occur.

117. (1.30) In the electrolysis of water, the addition of an acid affects the reaction by influencing

A. oxidation-reduction. **B.** polymerization.
C. the degree of isomerism.
D. the temperature at which water boils.
E. ionization.

118. (1.30) When $CaCO_3$ reacts with HCl the products are

A. CaCCl, water, and carbon dioxide.
B. CaHCl, water, and carbon dioxide.
C. $ClCO_3$, and CaH.
D. $CaCl_2$, water, and carbon dioxide.
E. CaCCl, and carbon dioxide.

119. (1.30) When hydrochloric acid is placed in water the solution will conduct a current. In so doing

A. the $H+$ goes to the anode and there gains an electron.
B. the $Cl-$ is reduced.
C. molecules of HCl are neutralized.
D. the HCl is not used up.
E. the valence of the chlorine is changed.

120. (1.30) The salt $NaHSO_4$ is formed rather than Na_2SO_4 in a neutralization reaction because

A. an excess of acid is present during the reaction.
B. the reaction is not allowed to go to completion.
C. the base is a strong base.
D. an excess of the base is present during the reaction.
E. the acid is only partially ionized.

121. (1.30) Electrolytic conduction involves

A. only electron changes between atoms and ions.
B. alteration of the number of protons in the atoms.
C. no chemical changes.
D. alteration of all the particles within the atom.
E. only the nucleus of the atom.

122. (1.30) In a solution of acid and base so mixed as to produce neutralization all of the following conditions exist ***except***

A. the solution will conduct an electrical current.
B. ions will be present.
C. the acid and base have given up their properties.
D. the necessity that a salt be present and composed of a part of the acid and a part of the base.
E. none of the above; all four conditions exist.

123. (1.30) A solution of a non-volatile solute in water

A. boils at 100°C.
B. always has a volume equal to the combined volumes of solute and solvent.
C. has a higher freezing point than water.
D. has a lower boiling point than water.
E. has a lower vapor pressure than water, at the same temperature.

Items 124 and 125.

Statement: Two dissimilar metal electrodes are placed in a solution of an electrolyte. The external ends of the electrodes are connected to the terminals of a galvanometer.

124. (1.10) *Effect:*

A. The galvanometer will flow.
B. The electrolyte will dissolve.
C. The metallic electrodes will dissolve.
D. A current will flow.
E. The solution will decompose due to electrolysis.

125. (1.30) *Cause:*

A. The electrolyte acts on the solvent.
B. The solution acts on the galvanometer.
C. Electrons are gained at one electrode and lost at the other.
D. The electrodes react with each other.
E. The galvanometer furnishes the current.

Items 126 - 137. After each item number on the answer sheet, blacken space

A. if the item at the left of the page is of greater magnitude than the item at the right.
B. if the item at the right of the page is of greater magnitude than the item at the left.
C. if the two items are of equal magnitude.

126. (1.30)	Amount of energy released when one gram of powdered iron burns in oxygen to iron oxide.	....	Amount of energy released when one gram of powdered iron rusts to iron oxide.

127. (1.30)	Extent to which compounds formed by electron sharing tend to ionize.	....	Extent to which compounds formed by electron transfer tend to ionize.
128. (1.30)	Mass of reacting substances.	....	Mass of new substances produced in the reaction.
129. (1.30)	Conductivity of an ionic compound dissolved in water.	....	Conductivity of a nonionic compound dissolved in water.
130. (1.30)	Number of electrons lost at the positive electrode in electrolysis.	....	Number of electrons gained at the negative electrode in electrolysis.
131. (1.30)	Molecules of a strong acid, such as HCl, in a water solution.	....	Hydrogen ions of a strong acid, such as HCl, in a water solution.
132. (1.30)	Effect of a 10°C. rise in temperature on the velocity of a given reaction.	....	Effect of a 20°C. rise in temperature on the velocity of the same reaction.
133. (1.30)	Velocity at which ionic compounds dissolved in water react together.	....	Velocity at which nonionic compounds dissolved in water react together.
134. (1.30)	Ease with which chloride ions give up electrons to form a free element.	....	Ease with which iodide ions give up electrons to form a free element.
135. (1.30)	Number of electrons lost in an oxidation reduction reaction.	....	Number of electrons gained in the same oxidation-reduction reaction.
136. (1.30)	Malleability and ductility of a metal.	....	Malleability and ductility of a non-metal.
137. (1.30)	Velocity of reaction between two ionic solids.	....	Velocity at which the same two ionic solids will react when dissolved in water.

Items 138 - 142. After each item number on the answer sheet, blacken space

A. if the item is true of such acids as hydrochloric (HCl), nitric (HNO_3), and sulfuric (H_2SO_4).
B. if the item is true of such an acid as acetic ($HC_2H_3O_2$).
C. if the item is true of all of the acids mentioned above.
D. if the item is true of none of the acids mentioned above.

138. (1.30) One of the ions is a proton.

139. (1.30) Acids of this type are slightly ionized in water solution.

140. (1.30) Acids of this type are completely ionized in water solution.

141. (1.30) Acids of this type will not conduct an electric current in water solution.

142. (1.30) Acids of this type will react with bases to form salts in water solution.

143. (1.30) Concentration usually is used to control an equilibrium. The equation for the dissociation of acetic acid is given by $HC_2H_3O_2 \rightleftarrows C_2H_3O_2^- + H^+$.

If a base like NaOH is added,

A. the concentration of the H^+ ions will be increased.
B. fewer acid molecules will dissociate.
C. the reaction to the right will increase.
D. no change will occur in the equilibrium.
E. it will act as a catalyst and hasten both reactions.

144. (1.30) If solid sodium acetate is dissolved in a solution of acetic acid,

A. no change of pH takes place.
B. the concentration of un-ionized acetic acid is decreased.
C. the hydronium ion concentration becomes the same as that of water.
D. more of the acetic acid is ionized.
E. the hydronium ion concentration is decreased.

145. (1.30) When electrovalent compounds dissolve

A. the molecules of the solute are dispersed in the solution.
B. the shared electrons fall apart.
C. a solvent of polar nature tends to gather around the ions of the crystal, so that the electrostatic force which holds the crystal together is no longer effective and the crystal disintegrates.
D. no ions are present in the solution.
E. such solutions are non-conductors.

146. (1.30) In the self-ionization of water

A. all the water molecules lose protons
B. the fact that water forms associated molecules is of prime importance.
C. water acts like a strong acid, but like a weak base.
D. the denominator in the equilibrium equation remains practically constant through all ranges of ionization.
E. at equilibrium, water has a pH of 10^{-14}.

147. (1.30) When a strong acid is neutralized by OH^- ions

A. the neutral point is reached when the hydronium ion concentration is 10^{-7}.
B. the weight of the acid required is always equal to the weight of the substance which furnishes the OH^- ions.
C. un-ionized salt is formed in all neutralizations.
D. in neutralizations in which sodium hydroxide is used, molecules of that substance act as the base.
E. only one hydronium ion in 555,000,000 reacts with OH^- ions.

148. (1.30) Water

A. both takes on and gives off protons.
B. takes on protons, but never gives them off.
C. gives off protons, but never takes them on.
D. neither takes on nor gives off protons.
E. can give off only those protons which it has taken on.

149. (1.30) Hydrogen sulfide

A. is a more effective precipitating agent in alkaline solution because of the larger concentration of hydrogen sulfide molecules present under such conditions.

B. is an amphiprotic substance like water.
C. has a higher boiling point than water because it is associated in the liquid state.
D. precipitates more metals in alkaline than in acid solution because more sulfide ions are formed under the former conditions.
E. shows sulfur with an oxidation state of +2.

150. (1.30) Aluminum hydroxide

A. is always a base-forming hydroxide.
B. never forms salts in which the aluminum is a part of the negative ion.
C. has no practical application.
D. in contact with acids, takes protons from them; in contact with bases gives protons to them.
E. acts neither as an acid nor as a base.

151. (1.30) An aqueous solution of disodium hydrogen orthophosphate

A. is neutral because the substance is a salt.
B. is alkaline because sodium hydroxide molecules are formed by hydrolysis.
C. is acid because $HPO_4^{=}$ can lose protons.
D. may be acid or alkaline according to its concentration.
E. is alkaline because $HPO_4^{=}$ tend to take protons from water molecules.

152. (1.30) An aqueous solution of sodium bicarbonate

A. has a pH greater than 7 because the bicarbonate ions pick up protons.
B. evolves carbon dioxide on boiling, forming a precipitate of sodium carbonate at the same time.
C. is alkaline because the bicarbonate ion forms carbonate ions to a limited extent by reaction with the water.
D. is used in water-softening.
E. may be made by the action of sodium carbonate on limestone.

Item 153 deleted.

154. (1.30) Which of the following solutions will be basic? (HCl is a strong acid, NaOH is a strong base and HAc is a weak acid.)

A. 0.01 molar HCl. **B.** 0.1 molar NaCl.
C. 0.1 molar NaAc. **D.** 0.1 molar HAc.
E. None; all are acidic.

155. (1.30) If ammonium chloride is dissolved in water what are all of the ions or molecules that will be present in detectable amounts? (NH_4OH is a weak base and HCl is a strong acid.)

A. NH_4^+, OH^-, H_3O^+, Cl^- and no others.
B. NH_4^+, OH^-, H_3O^+, Cl^-, HCl and no others.
C. NH_4^+, NH_4OH, H_3O^+, Cl^-, and no others.
D. NH_4^+, NH_4OH, H_3O^+, OH^-, Cl^- and no others.
E. NH_4OH, H_3O^+, Cl^- and no others.

156. (1.30) Which of the following is *not* true?

A. A strong acid ionizes completely in water.
B. A base reacts with an acid to give water and a salt.
C. A weak acid does not ionize in water.
D. A salt ionizes in water.
E. A base ionizes to give hydroxide ions in solution.

157. (1.10) In general, salts in solution are

A. highly ionized. **B.** highly associated.
C. slightly ionized. **D.** not ionized.

158. (1.30) The conclusion of item 157 is based on the experimental fact that

A. salts are soluble in water.
B. salts have a salty taste.
C. salts are the products of interaction of a base and an acid.
D. solutions of salts conduct electricity well.
E. salts contain positive and negative ions.

159. (2.00) Of the following methods, Lavoisier would best support his contention that the acidity of muriatic acid is due to the presence of oxygen by

A. showing that oxygenated muriatic acid is stronger than muriatic acid itself.
B. showing that all other oxygen-containing substances are acidic.
C. showing that other substances are capable of uniting with a sufficient amount of oxygen to form acids.
D. preparing muriatic acid by combining a non-acidic or weakly-acidic substance with oxygen.
E. isolating oxygen as a decomposition product of muriatic acid.

160. (2.00) The subsequent discovery that muriatic acid contains no oxygen

A. invalidates the criteria by which Lavoisier identified acids.
B. excludes muriatic acid from the class of acids.
C. necessitates postulating another element as the cause of acidity.
D. makes this one exception necessary to the theory that oxygen is the cause of acidity.
E. invalidates the oxygen theory of acidity but retains the criteria by which acids are recognized.

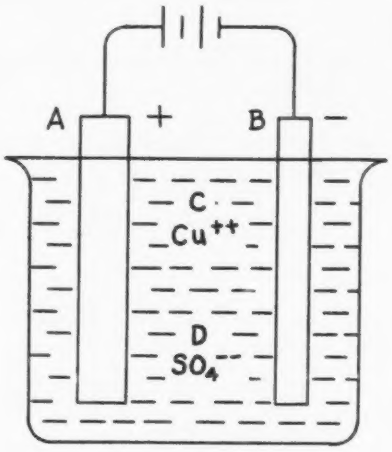
161. (2.00) Lavoisier states (p. 70), "... we cannot have the slightest doubt that it (muriatic acid), like all other acids is composed by the union of oxygen with an acidifiable base." This statement may be best characterized as

A. a tentative hypothesis designed to guide further investigation.
B. a redefinition of the term "acid" in terms of observables.
C. a conclusion arising from similarity of properties of muriatic acid and oxygen-containing acids.
D. an inference from experimental data on muriatic acid.
E. a necessary consequence of the theory that all substances containing a maximum amount of oxygen are acids.

162. (2.00) In view of the subsequent finding that muriatic acid contains no oxygen, which of the following comments is best justified?

A. Lavoisier erred in basing conclusions on qualitative rather than quantitative data.
B. Lavoisier violated his own precepts by making hypotheses.
C. Lavoisier's error demonstrates the need of an atomic theory as a guiding principle.
D. To the extent that a scientist may feel it unnecessary to prove all highly probable conclusions, Lavoisier was justified.
E. Lavoisier's entire scheme of classification is invalid, since it contains a false assumption.

Items 163 - 171. The sketch below represents a device for plating any metal object through use of a direct electric current. In this case the object is to be copper plated. After each item number on the answer sheet, blacken the *one* lettered space which designates the part of the diagram to which the item correctly refers.



163. (2.10) The electrode receiving electrons streaming through the wire to which it is connected.

164. (2.10) Electrode where ions may take up electrons.

165. (2.10) Ions which may take up electrons and form neutral atoms.

166. (2.10) Electrode which dissolves in accordance with this reaction, $Cu = Cu^{++} + 2e$.

167. (2.10) Ion which plays no part in the reaction.

168. (2.10) Electrode which is the object to be plated.

169. (2.10) If silver plating were to be carried out which ion would be replaced with the Ag^- ion from a silver compound?

170. (2.10) In silver plating which electrode would be metallic silver?

171. (2.10) Which electrode would be the object to be silver plated?

Items 172 - 175. A substance of formula C_2H_5OH is a liquid at room temperature. Its conductance is tested by connecting a light bulb, suitable source of current, and two electrodes that dip into the liquid, in series with each other. No glow whatever can be detected in the light bulb. Some water is then mixed with the liquid but this makes no difference nor visible change in the conductance. Assuming the above facts, answer the following:

172. (2.10) One can conclude that this substance will

A. change red litmus to faint blue.
B. have no effect on litmus.
C. change blue litmus to a faint pink.
D. change blue litmus to a strong red.
E. change red litmus to a strong blue.

173. (2.10) This substance is held together by

A. electrovalent bonds. **B.** covalent bonds.
C. ionic valence. **D.** inert bonds.
E. electrolytic bonds.

174. (2.10) The above substance may be called

A. a non-electrolyte. **B.** a strong electrolyte.
C. a weak electrolyte. **D.** a radical.

175. (2.10) The substance is

A. an acid. **B.** a base. **C.** a salt.
D. none of these types of compounds.

For items 176 - 184, refer to the list at the right.

A. $^{24}_{12}Mg$
B. $^{32}_{16}S$
C. $^{23}_{11}Na$
D. $^{35}_{17}Cl$
E. $^{63}_{29}Cu$

176. (2.10) This atom would lose one electron when it combined with a non-metal.

177. (2.10) This atom would gain two electrons when it united with a metal.

178. (2.10) The oxide of this element will form the strongest base when dissolved in water.

179. (2.10) Through gain of one electron, an atom of this element forms the negative ion of a strong acid when dissolved in water.

180. (2.10) This element would be highest in an activity list of metals.

181. (2.10) Oxygen acids of this element are used in ordinary storage batteries.

182. (2.10) This element would not replace hydrogen from acids.

183. (2.10) Neither dry table salt nor distilled water will alone conduct electrical currents but a solution of the two will. The reason for this is that

A. salt is an insulator.
B. the ions of sodium and chlorine move freely in a water solution.
C. the ions of sodium and chlorine cannot move in a dry salt crystal.
D. there is no way to connect an electrical conductor to dry salt.
E. there is a chemical action between salt and water.

184. (2.10) A certain chemical substance was described as capable of furnishing protons. It was *most* probably

A. a hydrocarbon. **B.** a salt. **C.** an acid.
D. a base. **E.** a non-polar compound.

185. (2.10) The term, neutralization, means

A. the addition of an acid or a base to a system by means of a burette.
B. the combination of a proton with an acid ion.
C. the combination of a proton with an hydroxyl ion.
D. the removal of all ions from a system.
E. the removal of salt(s) from water to make it suitable for drinking purposes.

For items 186 - 188, choose from the key list the term most closely related to the statements.

KEY

A. Catalysis. **B.** Hydrolysis. **C.** Electrolysis.
D. Diffusion. **E.** Dialysis.

186. (2.10) A reaction in which a normal salt reacts with water to form either an acidic or basic solution.

187. (2.10) Mixing of two substances by molecular motion.

188. Changing the rate of a reaction by using a substance
(2.10) that remains unchanged after completion of the reaction.

189. If an atom of lithium combines with one of fluorine to
(2.10) form LiF, the Li in the LiF is

A. non-metallic in character. **B.** a reducing agent.
C. in an ionized state. **D.** of negative valence.
E. reduced.

190. If potassium hydroxide is completely ionized and $K_w = 10^{-14}$, the pH of a solution containing 0.1 mole per
(2.10) liter of potassium hydroxide will be

A. 1. **B.** 13. **C.** 14. **D.** 12. **E.** 2.

191. If the H_3O^+ concentration in a particular water solu-
(2.10) tion is 10^{-9} molar what must the hydroxide ion concentration be?

A. 10^{-5}. **B.** 10^{-4}. **C.** 10^{-7}. **D.** 10^{-9}.
E. none of the above.

192. The following equation is true:
(2.10) $H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$

A 2 molar sulfuric acid solution is

A. 1 normal. **B.** 2 normal.
C. 3 normal. **D.** 4 normal.
E. The normality cannot be determined from the information given.

193. Both washing soda (Na_2CO_3) and baking soda
(3.00) ($NaHCO_3$) yield CO_2 when treated with acids. If equal weights of both compounds are treated with acid,

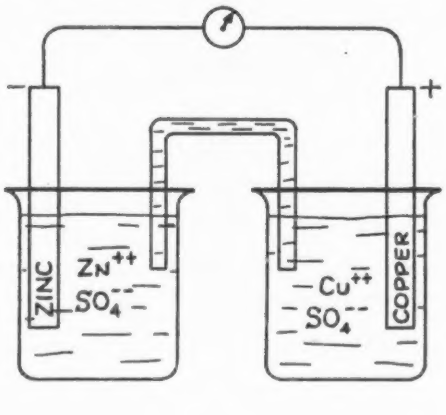
A. the baking soda will yield the most CO_2.
B. the washing soda will yield the most CO_2.
C. equal weights of CO_2 will be obtained.

194. The reaction of sodium hydroxide and hydrochloric
(3.00) acid is given by the equation: $NaOH + HCl \rightarrow NaCl + H_2O$. How many grams of NaOH are needed to produce 100 grams of NaCl? (Atomic weights, Na = 23, O = 16, H = 1, Cl = 35.5.)

A. 68.4. **B.** 52.3. **C.** 30.6. **D.** 23.4.
E. none of these.

Items 195 - 202. After each item number on the answer sheet, blacken space

A. if the item is true of atoms of copper in the copper electrode.
B. if the item is true of copper ions in the Cu^{++}, SO_4^{--} solution.
C. if the item is true of zinc ions in the Zn^{++}, SO_4^{--} solution.
D. if the item is true of zinc atoms in the zinc electrode.
E. if the item is true of the SO_4^{--} ions.



195. Substance which releases the electrons.
(3.00)

196. Ions which gain electrons and which are deposited as
(3.00) neutral atoms.

197. Atoms which give up electrons and form positive ions.
(3.00)

198. In the entire apparatus, the total number of these ions
(3.00) does not decrease.

199. Ion whose concentration increases as the cell is in
(3.00) operation.

200. Ion whose concentration decreases as the cell is in
(3.00) operation.

201. The ion which passes from the copper sulfate beaker to
(3.00) the zinc sulfate beaker.

202. The answer listed above which refers to the metal higher
(3.00) in the electrochemical series.

203. Of two solutions, one containing 50 g. of sulfuric acid
(3.00) in 100 g. of water and the other containing 10 g. of ammonia in 100 g. of water (at. wts., H = 1, S = 32, O = 16, N = 14), the solution of the larger molecular concentration is that of

A. H_2SO_4. **B.** NH_3. **C.** they are the same.
D. not enough information is given for a correct answer.
E. the answer depends upon the barometric pressure.

204. In neutralizing 50 ml. of a solution of NaOH contain-
(3.00) ing 0.5 mole per liter the volume of 2.0 molar HCl required will be

A. 25 ml. **B.** 100 ml. **C.** 12.5 ml.
D. 20 ml. **E.** none of these figures.

205. If solid sodium acetate is dissolved in a solution of
(3.00) acetic acid

A. no change of pH takes place.
B. the concentration of un-ionized acetic acid is decreased.
C. the hydronium ion concentration becomes the same as that of water.
D. more of the acetic acid is ionized.
E. the hydronium ion concentration is decreased.

206. How many milliliters of 3 molar HCl are required to
(3.00) neutralize 500 milliliters of 2 molar NaOH?

A. 300 ml. **B.** 333 ml. **C.** 660 ml.
D. 375 ml. **E.** 750 ml.

207. Aluminum reacts with HCl according to the equation
(3.00) $Al + HCl = AlCl_3 + H_2$ (not balanced)

One gram atom of aluminum will liberate how many grams of hydrogen if an excess of HCl is present?

A. 1 gram. **B.** 2 grams. **C.** 3 grams.
D. 4 grams. **E.** 6 grams.

208. The atomic weight of chlorine is 35. If as in item 207
(3.00) above, one gram atom of aluminum reacts with an excess of HCl how many grams of HCl will be used up?

A. 12 grams. **B.** 18 grams. **C.** 36 grams.
D. 62 grams. **E.** 108 grams.

209. (3.00) From consideration of the molecular compositions concerned, deduce the number of molecules of the compound KOH which could be formed by combining 4 molecules of the compound K_2O with the required amount of water.

A. 1. **B.** 2. **C.** 8. **D.** 4. **E.** 16.

Items 210 and 211. An aqueous solution contains 1 gram-molecular weight of nitric acid (HNO_3) in 1 liter of solution, and a second solution contains 1 gram-molecular weight of sodium hydroxide (NaOH) in 1 liter of solution.

210. (3.00) How much of the base solution will be needed exactly to neutralize 10 cubic centimeters of the acid solution? (Answer in cubic centimeters.)

A. 10. **B.** 20. **C.** 15. **D.** 40. **E.** 5.

211. (3.00) If the water is evaporated from the neutralized mixture, what substance will crystallize out?

A. H_2O. **B.** $NaNO_3$. **C.** NaH. **D.** Na_2NO_3. **E.** $Na(NO_3)_2$.

27. *Carbon Compounds; Silicon Compounds*

CARBON COMPOUNDS;
SILICON COMPOUNDS

1. (1.10) When carbon forms a series of compounds, each differing from the preceding one by the same change in formula, the process is called

A. isomerism. **B.** isostasy. **C.** homology.
D. hydrogenation. **E.** carbonation.

2. (1.10) A silicone is

A. an element. **B.** a compound. **C.** a mixture.
D. a rock. **E.** two of the above.

3. (1.10) Vegetable cooking oils are now processed from cotton seed oil by

A. precipitation. **B.** hydrogenation.
C. partial oxidation. **D.** reduction. **E.** sublimation.

4. (1.10) All of these are chemical formulas of ordinary fuels *except*

A. CO. **B.** CH_4. **C.** CO_2. **D.** C_2H_5OH.
E. C_7H_{16}.

5. (1.10) The first member of a series of compounds in which each member differs from each successive member by the same change in formula is

A. H_2SO_4. **B.** $NaOH$. **C.** CH_4. **D.** H_2CO_3.
E. HNO_3.

6. (1.10) Charcoal is made by a process known as

A. carbonation. **B.** destructive distillation.
C. organic synthesis. **D.** hydrogenation.
E. hydration.

7. (1.10) Cracking of petroleum oils is an important method for making

A. synthetic fuels. **B.** producer gas. **C.** kerosene.
D. coal gas. **E.** gasoline.

Items 8 - 11 are concerned largely with carbon compounds. Select from the key the most closely related term.

KEY

A. Hydrogenation. **B.** Homology. **C.** Polymerization.
D. Isomerism. **E.** None of these.

8. (1.10) Molecules of a substance may add to each other to produce molecules of greatly increased molecular weight.

9. (1.10) Many new plastic products are the result of such reactions.

10. (1.10) Compounds with the same formula but a different arrangement of their atoms.

11. (1.10) Alternate forms of an element with the same number of protons but a slightly different number of neutrons.

12. (1.10) Which one of these produces molecules of tremendous molecular weight?

A. Polymerization. **B.** Hydrogenation. **C.** Homology.
D. Hydration. **E.** Carbonation.

13. (1.10) The basic or simplest member of an homologous series of compounds is

A. H_2SO_4. **B.** $NaOH$. **C.** CH_4. **D.** H_2CO_3.
E. HNO_3.

14. (1.10) It is possible for

A. a strong acid to react as a base in the presence of another acid to form a salt and water.
B. a carbohydrate to be synthesized from carbon dioxide and water in the laboratory.
C. two hydrocarbons to have the same formula but different molecular structures.
D. protein to consist only of carbon, hydrogen and oxygen.
E. all of the above are possible.

15. (1.10) An essential element in every organic compound is

A. oxygen. **B.** hydrogen. **C.** carbon.
D. potassium. **E.** calcium.

16. (1.10) The study of carbon compounds is known as

A. organic chemistry. **B.** inorganic chemistry.
C. physical chemistry. **D.** quantitative chemistry.
E. qualitative chemistry.

17. (1.10) When one buys a pound of dry ice, he is really buying

A. water. **B.** hydrogen. **C.** nitrogen.
D. carbon. **E.** carbon dioxide.

18. (1.10) The chief constituent of natural gas is

A. Butanol. **B.** Methane. **C.** Methanol. **D.** Butane.

19. (1.10) Compounds consisting entirely of hydrogen and carbon are known as

A. carbohydrates. **B.** hydrates. **C.** hydrocarbons.
D. carbonates.

20. (1.10) Carbon dioxide in the air

A. is being continually added to by the vital processes of plants.
B. is always large at the dew point.
C. is the source of all the carbon in plants.
D. may be absorbed by the action of P_2O_5 upon it.
E. varies very widely in amount from place to place.

21. (1.10) An unsaturated hydrocarbon

A. is one in which the carbon atoms are combined by sharing a single electron.
B. is always a branched-chain hydrocarbon.
C. contains double bonds.
D. is one which forms unsaturated solutions.
E. is always formed by the union of two or more benzene rings.

22. (1.10) A homologous series of hydrocarbons

A. is one in which each member differs from the next preceding one by the combination CH_2.
B. is made up entirely of the derivatives of benzene.
C. always has the general formula C_nH_n.
D. is made up of a given hydrocarbon and its isomers.
E. is confined to the straight-chain hydrocarbons.

23. Petroleum
(1.10)

A. is a liquid of constant boiling point.
B. consists primarily of unsaturated hydrocarbons.
C. consists of a mixture of hydrocarbons whose molecular weight is less than 150.
D. contains both branched and straight chain compounds.
E. is best refined by fractional crystallization.

24. The octane number of a motor fuel is
(1.10)

A. the percentage of octane in the fuel.
B. the percentage of iso-octane in a mixture of it and normal heptane which gives the same knock as does the fuel.
C. the boiling point of the fuel in centigrade degrees.
D. the percentage of tetraethyl lead in the fuel.
E. never over 100.

25. *One* of the following statements concerning fuel gasses is correct.
(1.10)

A. water gas is composed of hydrogen and oxygen.
B. acetylene is made by the action of water on silicon carbide.
C. producer gas has a higher fuel value than any other common fuel gas.
D. natural gas contains little or no carbon monoxide.
E. coal gas is made by heating coal in an abundant supply of air.

26. Proteins
(1.10)

A. are substances of high molecular weight which are found only in animal tissues.
B. are an important element of diet because vitamins are mostly derived from them.
C. are big molecules containing nitrogen which supply most of the energy in a typical human diet.
D. are hydrolyzed during digestion into their constituent amino acids.
E. can be built up by animals from fats and ammonium salts.

27. One of the following statements is *not* correct.
(1.10)

A. The vital action in plants is mainly the building of complex substances from simple ones.
B. Carbohydrates contain hydrogen and oxygen in the proportion of two atoms of hydrogen to one of oxygen.
C. Fats are esters.
D. Proteins are relatively simple hydrocarbons.
E. In animals complex vegetable materials are broken down into smaller molecules and reconstructed into bigger ones.

28. In photosynthesis
(1.10)

A. an endothermic reaction promoted by light builds up sugars from carbon dioxide and water.
B. proteins are hydrolyzed to amino acids by sunlight.
C. plants evolve large quantities of heat which the large area of their leaves helps to dissipate.
D. bacteria in the roots of certain plants turn atmospheric nitrogen into nitrites.
E. roots pick up inorganic salts from the soil.

29. Silica
(1.10)

A. is notable for a high coefficient of thermal expansion.
B. consists of chains of silicon atoms, giving it a fibrous structure.
C. is much harder than quartz.
D. decomposes at red heat into its elements.
E. is transparent to ultraviolet light.

30. Silicon carbide
(1.10)

A. contains oxygen. **B.** is used as a lubricant.
C. is a conductor of electricity.
D. is made by the action of coke on silica.
E. is harder than the diamond.

31. In mineral silicates
(1.10)

A. silicon atoms are bound together directly, atom to atom.
B. SiO_4 ions are bound together, through sharing oxygen atoms.
C. most silicates are soluble in water.
D. if the binding of the silicate ions takes place in one direction only, the mineral exists in plates.
E. the most abundant of the mineral silicates is the uncombined silicate ion.

32. Water glass
(1.10)

A. is ordinary glass which has been hydrated.
B. is used as an adhesive.
C. is made by dehydrating silicic acid.
D. has a high melting point.
E. is a type of glass with a very high (95%) silica content.

33. Glass
(1.10)

A. is a compound having a definite chemical formula.
B. is a mixture of salts resulting from the process of heating together acidic and basic oxides.
C. has a fixed melting point.
D. is made up of individual crystals.
E. never is made of other ingredients than limestone, soda and silica.

34. Which of the following compounds are we most likely to find in petroleum?
(1.10)

A. NaCl. **B.** $CHCl_3$. **C.** C_8H_{18}. **D.** CH_5N.
E. $C_6H_{13}OH$.

35. Select the true statement or statements.
(1.10)

a. Bituminous coal contains fixed nitrogen.
b. Anthracite coal is over 90% carbon.
c. When melted, coke becomes coal tar.

The correct selection includes only

A. a. **B.** b. **C.** c. **D.** a and b. **E.** b and c.

36. Select the true statement or statements.
(1.10)

a. Petroleums may be classified as paraffin base or asphalt base.
b. Petroleum deposits occur in sedimentary rock.
c. During the distillation of petroleum the aromatic hydrocarbons are separated from the paraffin hydrocarbons.

The correct selection includes

A. only a. **B.** only b. **C.** only c.
D. only a and b. **E.** a, b, and c.

37 and 38. The molecular diagram of a certain hydrocarbon consists of a ring of six carbon atoms, all joined together by single valence bonds.

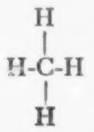
37. (1.23) Under which type of molecular pattern should the certain hydrocarbon be classed?

A. Normal paraffin. **B.** Normal olefine.
C. Normal di-olefine. **D.** Cyclo-paraffin.
E. Aromatic.

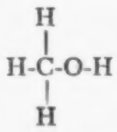
38. (1.10) How many hydrogen atoms would the molecule contain?

A. 24. **B.** 6. **C.** 8. **D.** 12. **E.** 14.

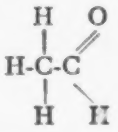
Items 39 and 40 are based on the following compounds which are known to exist.



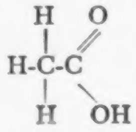
(A)



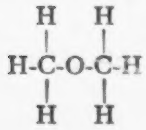
(B)



(C)



(D)



(E)

39. (1.23) Which of the above compounds is called an alcohol?

A. A. **B.** B. **C.** C. **D.** D. **E.** E.

40. (1.23) Which of the above compounds is called an acid?

A. B. **B.** C. **C.** D. **D.** E.
E. None of these.

41. (1.23) Consider the following reaction:

$C_{12}H_{26} \rightarrow C_6H_{14} + C_6H_{12}$.

Which one of the following processes does the reaction illustrate?

A. Polymerization. **B.** Cracking.
C. Hydrogenation. **D.** Neutralization.
E. Substitution.

42. (1.25) In the cracking of petroleum

A. the *average* molecular weight of the hydrocarbon mixture is unchanged.
B. long-chain hydrocarbons are broken into shorter chain varieties.
C. the process is now obsolete because of the use of tetraethyl lead.
D. short chains are combined to form ring compounds.
E. the boiling point of the product is higher than that of the uncracked material.

43. (1.25) Portland cement is made by heating together

A. sand, limestone, soda. **B.** sand, clay.
C. coke, iron ore, limestone. **D.** clay, limestone.
E. sand, coke, soda.

44. (1.25) The Fischer-Tropsch process

A. produces gasoline by passing hydrogen through powdered coal at atmospheric pressure.
B. consists in the controlled distillation of coal so as to produce a high percentage of octanes in the distillate.
C. is an economical method of making gasoline from oil shales.
D. produces a variety of hydrocarbons by passing water gas over a hot catalyst at atmospheric pressure.
E. is a method of improving the octane number of gasoline.

45. (1.30) Carbon forms a large number of compounds because

A. of its small ionic radius.
B. of its great chemical activity.
C. it shows many valences.
D. of the ability of carbon atoms to form covalent linkages with each other.
E. it forms electrovalent and covalent compounds with equal ease.

46. (1.30) Select the true statement or statements (if any) of those below.

a. Vertebrate animals are able to synthesize all necessary proteins from atmospheric nitrogen.
b. All chlorophyll-containing plants can synthesize proteins directly from atmospheric nitrogen.
c. In general, animals can synthesize all necessary proteins from inorganic nitrogen compounds.

The correct selection includes

A. only a. **B.** only b. **C.** only c.
D. only b and c. **E.** none of them.

47. (2.10) The per cent of carbon in methane is

A. 25%. **B.** 20%. **C.** 75%. **D.** 133%. **E.** 300%.

Items 48 - 51. Indicate the most closely related word or phrase from the key below.

KEY

A. Catalysis. **B.** Presence of C, H and O.
C. Presence of OH.
D. Presence of OH^- groups (ions)
E. Presence of double bonds.

48. (2.10) Alcohols. **49.** (2.10) Alkali.

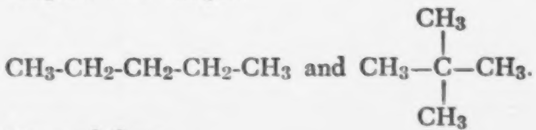
50. (2.10) Carbohydrates. **51.** (2.10) Unsaturation.

Items 52 - 54 refer to various types of carbon compounds. For each item select from the key the most appropriate response.

KEY

A. C_3H_8 and C_4H_{10}. **B.** $C_6H_{12}O_6$ and $6CH_2O$.
C. CH_3OH and CH_3Cl.

D.



$CH_3\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}CH_3$ and $CH_3-\overset{\displaystyle CH_3}{\underset{\displaystyle CH_3}{C}}-CH_3$.

E. None of these.

52. (2.10) A pair of compounds showing isomeric properties.

53. A pair of compounds classed as proteins.
(2.10)

54. A pair of compounds which are members of an homologous series.
(2.10)

Items 55 - 58. Choose from the key list that term most closely related to the statements.

KEY

A. Hydrocarbon. **B.** Alcohol. **C.** Aldehyde.
D. Acid. **E.** Ether.

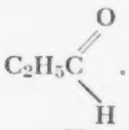
55. A carbon-hydrogen compound that has undergone the most oxidation.
(2.10)

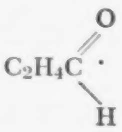
56. A carbon-hydrogen compound that has undergone only the initial stage of oxidation.
(2.10)

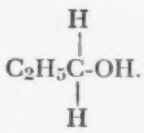
57. The group of compounds with greatest use in the plastics industry and closely related to the sugars.
(2.10)

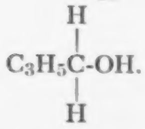
58. An organic compound that contains no oxygen.
(2.10)

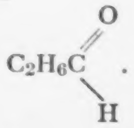
59. Carefully-controlled oxidation of normal propyl alcohol produces an aldehyde containing the same number of carbon atoms in the molecule as does the propyl alcohol. Deduce the molecular composition of the aldehyde. It is
(2.10)

A.

$C_2H_5C{}^{\diagup\!\!\diagup O}_{\diagdown H}$.

B.

$C_2H_4C{}^{\diagup\!\!\diagup O}_{\diagdown H}$.

C.

$C_2H_5\overset{H}{\underset{H}{C}}\text{-OH.}$

D.

$C_3H_5\overset{H}{\underset{H}{C}}\text{-OH.}$

E.

$C_2H_6C{}^{\diagup\!\!\diagup O}_{\diagdown H}$.

60. A number of marvelous new plastics and lubricants are being produced which contain the element, silicon. Which of the following facts probably most stimulated the research which led to this development?
(2.30)

- **A.** Silicon (or silicon dioxide) is a constituent of numerous minerals.
- **B.** Silicon compounds are very abundant.
- **C.** Silicon's position in the Periodic Table shows that its properties are in many respects similar to carbon.
- **D.** Silicon compounds and petroleum occur together in nature.
- **E.** Our petroleum resources are being depleted rapidly.

Items 61 - 63. The complete combustion of heptane (C_7H_{16}) yields carbon dioxide (CO_2) and water (H_2O).

61. How many carbon dioxide molecules are formed from each molecule of heptane?
(3.00)

A. 1. **B.** 16. **C.** 14. **D.** 7. **E.** 8.

62. How many water molecules are formed from each molecule of heptane?
(3.00)

A. 1. **B.** 16. **C.** 14. **D.** 7. **E.** 8.

63. How many *atoms* of oxygen are needed for complete combustion of one molecule of heptane?
(3.00)

A. 22. **B.** 11. **C.** 3. **D.** 7. **E.** 8.

64. All of these terms apply to an important class of chemical compounds *except*
(4.10)

- **A.** pairs of shared electrons.
- **B.** formation of ionized solutions.
- **C.** atoms forming rings of various sizes.
- **D.** formation of homologous series.
- **E.** atoms forming chains.

65. Which of the following is characteristic of carbon compounds?
(4.20)

- **A.** Carbon atoms join other carbon atoms only in such manner as to form chain compounds.
- **B.** Once a carbon compound is formed it cannot be chemically changed unless some atoms are removed.
- **C.** Once a carbon compound is formed it cannot be chemically changed unless some atoms are added.
- **D.** Many carbon compounds are soluble in water.
- **E.** Carbon atoms may share from one to eight valence bonds with other carbon atoms.

66. The most valuable effect of Friedrich Wohler's laboratory synthesis of urea was probably that of
(6.20)

- **A.** making available to agriculture nitrogenous fertilizers.
- **B.** clarifying the action of the nitrogen fixing bacteria.
- **C.** dissolving the barrier between organic and inorganic matter.
- **D.** clarifying the sequence of protein digestion and excretion of nitrogenous wastes.
- **E.** enabling the development of a convenient diagnosis for sugar diabetes.

28. *Periodic Law*

PERIODIC LAW

1. (1.10) The modern form of the periodic law states that the properties of the elements are a periodic function of their

A. atomic volume. **B.** ionization potential.
C. atomic weight. **D.** atomic number.
E. valence.

2. (1.10) Elements that lose electrons from more than one electronic energy level in ordinary chemical reactions are called the

A. alkali elements. **B.** alkaline earth elements.
C. light elements. **D.** radioactive elements.
E. transition elements.

3. (1.10) The columns of the modern periodic table contain elements which resemble each other in

A. molecular weight. **B.** valence.
C. the number of neutrons. **D.** appearance.
E. density.

4. (1.10) The vertical groups of the Periodic Chart consist of elements that have the

A. same number of electrons in the outer shell.
B. same number of electrons in the nucleus.
C. same number of planetary electrons.
D. same number of neutrons.

5. (1.10) If a diagonal line is drawn from the upper left hand corner to the lower right in the periodic table, elements will be found along the line

A. of the same valence.
B. which in oxide form produce only acids in solution.
C. which have both metallic and non-metallic properties.
D. which will include the most active metal.
E. with similar properties.

6. (1.10) Mendeleef

A. showed that there were fifteen rare earth elements.
B. predicted the existence of the inert gases.
C. proved that there were 92 elements.
D. discovered the elements gallium, scandium and germanium.
E. corrected the values of certain atomic weights.

7. (1.30) In the family of elements comprising the best oxidizing agents, oxidizing power

A. increases as the valence increases.
B. is greatest with oxygen.
C. increases as the atomic weight increases.
D. increases as the substance increases in metallic properties.
E. increases as the atomic number decreases.

8. (1.30) Which one of these is *not* true concerning the periodic table?

A. The series vary in the number of elements each contains.
B. Except for inert elements those elements at the left tend to lend electrons.
C. Except for inert elements those elements at the left are reducing agents.
D. Elements in group IIa are more active than those in Ia.
E. With increase in atomic number, chemical activity of the active metals increases.

9. (1.30) A series of elements in the periodic chart has atomic numbers: 10, 11, 12, 13, 14, 15, 16, 17. The one true statement about this series is that

A. the valence is constant for the series.
B. they are all metals.
C. the valence steadily decreases from left to right.
D. each element belongs to a different group.
E. the activity steadily increases from left to right.

10. (1.30) In the family of the most active metals in the periodic table, activity increases

A. with increase in valence.
B. as one reads from left to right.
C. as the atomic number decreases.
D. as one proceeds from top to bottom.
E. as the number of electron rings decrease.

Items 11 - 14 refer to the periodic chart. For each item select the correct response.

KEY

A. Left to right. **B.** Right to left.
C. Top to bottom. **D.** Bottom to top.
E. Two of these.

11. (1.30) Activity decreases but valence remains constant.

12. (1.30) Metallic character increases but valence remains constant.

13. (1.30) Oxidizing power increases but valence remains constant.

14. (1.30) The number of electronic shells increases.

15. (1.30) In the periodic table

A. the recent discovery of elements with higher atomic weights than uranium has thrown grave doubts on its validity.
B. the transition elements are elements having an outer shell of eight electrons.
C. the valence towards oxygen increases steadily from left to right across the table.
D. only gaseous elements are found in the short periods.
E. the rare earths discovered since Mendeleef are placed in single group to the right of Group VII.

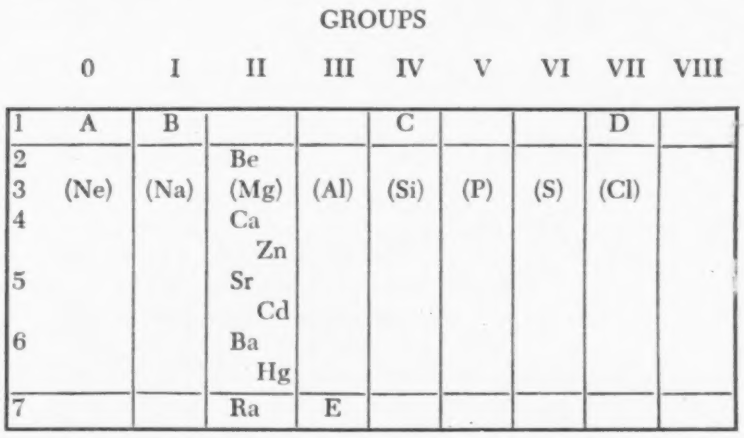
16. (2.10) Of the following, the element most similar to selenium (Se) would most likely be

A. oxygen (O). **B.** tellurium (Te). **C.** arsenic (As).
D. bromine (Br). **E.** krypton (Kr).

17. (2.10) Of the following, the element most similar to Rhodium, (Rh), would most likely be

A. Palladium (Pd). **B.** Platinum (Pt).
C. Iridium (Ir). **D.** Osmium (Os). **E.** Cobalt (Co).

Items 18 - 24 refer to the following diagram of the periodic chart in which certain areas are blocked off and numbered from A to E. Area E overlaps several of the other areas. The elements in group II and series 3 are also listed. For each item select the letter of the area to which it applies and record on the answer sheet.



GROUPS

	0	I	II	III	IV	V	VI	VII	VIII
1	A	B			C			D	
2			Be						
3	(Ne)	(Na)	(Mg)	(Al)	(Si)	(P)	(S)	(Cl)	
4			Ca Zn						
5			Sr Cd						
6			Ba Hg						
7			Ra	E					

18. All organic compounds contain one element from this
(2.10) area and most rocks contain another from the same area.

19. As one proceeds from one element to another in this
(2.10) area, the number of electrons in the outermost shell increases.

20. All elements in this area are metals.
(2.10)

21. An element in this area was discovered in the sun before
(2.10) it was found on earth.

22. Near the top of this area, compounds of the elements
(2.10) are formed by sharing electrons.

23. The halogens are located in this area.
(2.10)

24. Most radioactive elements are found in this area.
(2.10)

Items 25 - 30 refer to this section of the periodic chart. The first horizontal line shows series 2 and the second line indicates series 3 without proper symbols.

GROUPS

	0	I	II	III	IV	V	VI	VII
Series 2	He	Li	Be	B	C	N	O	F
Series 3	t	x	y	q	d	e	r	g

25. The most probable formula for a compound of x and g is
(2.10)

A. x_2g. **B.** xg. **C.** xg_2. **D.** x_3g_2.
E. unpredictable.

26. The most active metal of the following is
(2.10)

A. d. **B.** y. **C.** x. **D.** t. **E.** g.

27. Which one of the following is the best reducing agent?
(2.10)

A. g. **B.** t. **C.** y. **D.** x. **E.** r.

28. Which one of the following will form several series of
(2.10) compounds by sharing electrons?

A. d. **B.** y. **C.** g. **D.** t. **E.** x.

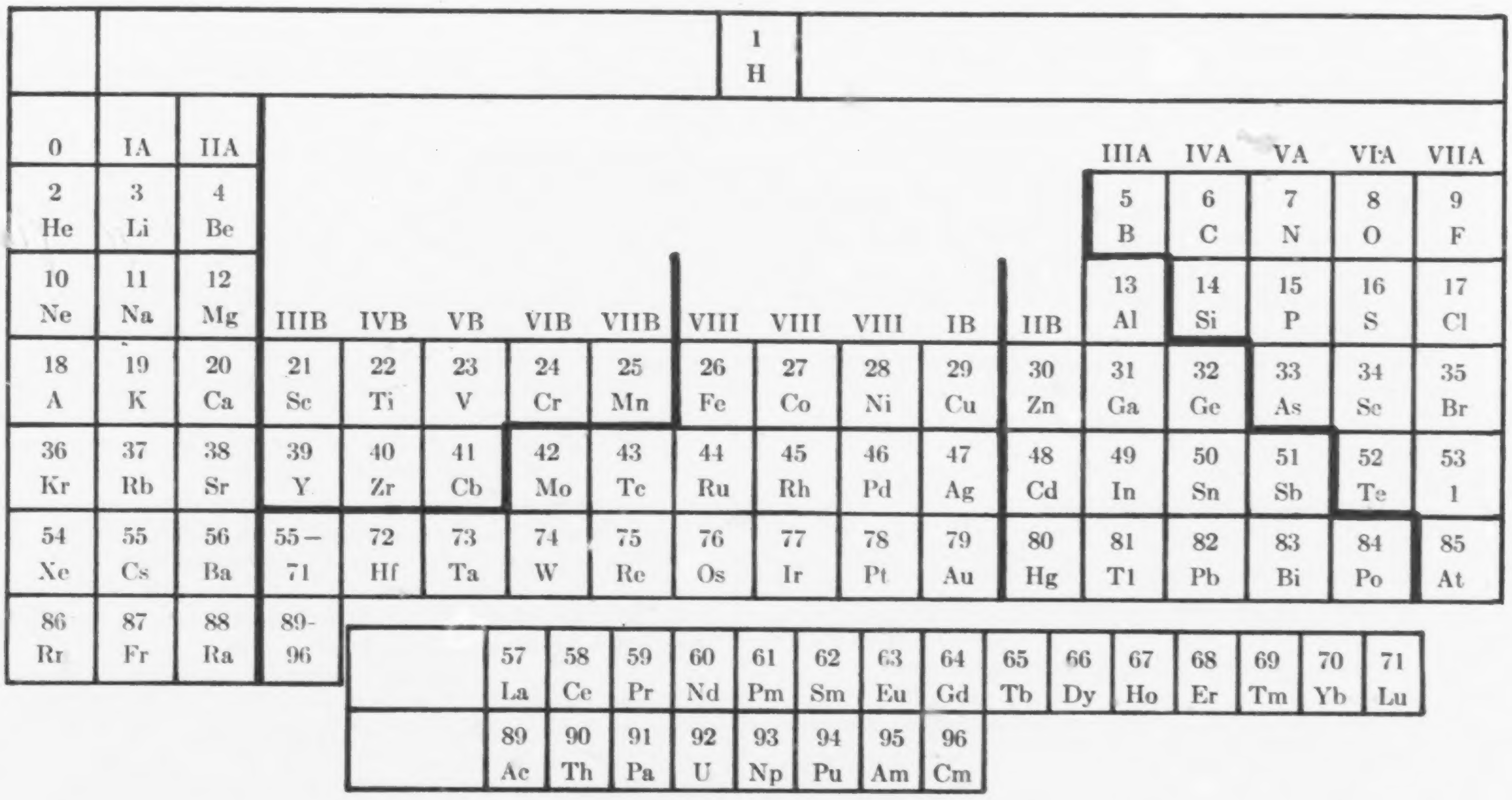
29. Which one of the following will borrow electrons most
(2.10) readily?

A. t. **B.** q. **C.** x. **D.** r. **E.** g.

30. Which one of the following has the greatest atomic
(2.10) radius?

A. g. **B.** r. **C.** t. **D.** q.
E. all of the above have the same radius.

Items 31 - 40 refer to the following.



									1 H								
0	IA	IIA											IIIA	IVA	VA	VIA	VIIA
2 He	3 Li	4 Be											5 B	6 C	7 N	8 O	9 F
10 Ne	11 Na	12 Mg	IIIB	IVB	VB	VIB	VIIB	VIII	VIII	VIII	IB	IIB	13 Al	14 Si	15 P	16 S	17 Cl
18 A	19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br
36 Kr	37 Rb	38 Sr	39 Y	40 Zr	41 Cb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I
54 Xe	55 Cs	56 Ba	55 — 71	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At
86 Rr	87 Fr	88 Ra	89- 96														

57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm							

The numbers in the Modern Periodic Table given above are the atomic numbers of the elements. After each exercise number on the answer sheet, blacken the *one* lettered space which designates the correct answer. (The numbers given in the listed answers are the atomic numbers of certain elements.)

A. 93, 94, 95, 96. **B.** Elements of group IA.
C. Elements of group VIIA.
D. 2, 10, 18, 36, and 54.
E. 11, 12, 13, 14, 15, 16, and 17.

31. (2.10) In this sequence of elements, the larger the atomic number, the greater the tendency to lose electrons.

32. (2.10) All of the elements in this sequence are inert.

33. (2.10) All of these elements have been synthesized and none occur in nature.

34. (2.10) Electrons in the outermost energy level increase from one to as many elements as are listed in the answer.

35. (2.10) In this sequence of elements, the smaller the atomic number, the greater the tendency to gain electrons.

A. 26, 27, 28, 42, and 78.
B. Elements in groups IA and IIA.
C. 6, 14, 12, and 20. **D.** 13, 31, 49, and 81.
E. 6, 7, 16, and 17.

36. (2.10) In general, the hydroxides of these elements are strong bases.

37. (2.10) These elements form the negative ions, or part of the negative ions, of certain acids widely used in industry.

38. (2.10) These elements are some of the ductile heavy metals of industrial importance.

								1 H									
0	IA	IIA											IIIA	IVA	VA	VIA	VIIA
2 He	3 Li	4 Be											5 B	6 C	7 N	8 O	9 F
10 Ne	11 Na	12 Mg	IIIB	IVB	VB	VIB	VIIB	VIII	VIII	VIII	IB	IIB	13 Al	14 Si	15 P	16 S	17 Cl
18 A	19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br
36 Kr	37 Rb	38 Sr	39 Y	40 Zr	41 Cb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I
54 Xe	55 Cs	56 Ba	55–71	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At
86 Rn	87 Fr	88 Ra	89–96														

	57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
	89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm							

39. (2.10) In these elements the number of electron orbits are respectively, 3, 4, 5, and 6.

40. (2.10) One of these elements is a constituent of all plant and animal tissue while the others are major constituents of various rocks.

Items 41 - 55 refer to the following.

The numbers in the Modern Periodic Table given above are the atomic numbers of the elements. After each exercise number on the answer sheet, blacken the *one* lettered space which designates the correct answer. (The numbers given in the listed answers are the atomic numbers of certain elements.)

41. (2.10) Electrons in the second energy level increase from one to seven.

42. (2.10) All of these elements with one exception contain 8 electrons in their outermost energy levels.

43. (2.10) All of these elements have been synthesized rather than found in natural sources.

44. (2.10) In this sequence of elements, the *larger* the atomic number the greater the tendency to *lose* electrons.

45. (2.10) In this sequence of elements, the *smaller* the atomic number the greater the tendency to *gain* electrons.

A. 93, 94, 95, and 96.
B. Elements in group VIIA.
C. 3, 4, 5, 6, 7, 8, and 9.
D. Elements in group IA.
E. Elements in group O.

46. (2.10) These elements are *some* of the non-metals.

47. (2.10) These elements, from different groups, are *some* of the light metals.

48. (2.10) These elements are some of the ductile heavy metals.

49. (2.10) These are naturally radioactive elements.

50. (2.10) The numbers of *energy levels* of these elements are successively 2, 3, 4, 5, 6, and 7.

A. 88, 89, 90, 91, and 92.
B. 3, 11, 12, 19, 20, and 56.
C. Elements in group IIA.
D. 6, 7, 8, 14, 16, 17, and 53.
E. 26, 27, 28, 42, and 78.

---

51. (2.10) When these elements form ions, through loss of one or more electrons, the ions have structures similar to the atoms of the inert gases.

52. (2.10) These elements are often referred to as the "halogens."

53. (2.10) These elements form the negative ions, or part of the negative ions, of certain common acids.

54. (2.10) One of these elements is a constituent of all plant and animal tissue while the other elements are major constituents of various rocks.

55. (2.10) Some of these metallic elements are used in producing important steel alloys.

A. 6, 14, 12, and 20.
B. 6, 7, 16, and 17.
C. 9, 17, 35, 53, and 85.
D. Elements in the B subgroups.
E. Elements in groups IA and IIA.

Items 56 - 63. After each item number on the answer sheet, blacken space

A. if the item is true of metals.
B. if the item is true of non-metals.
C. if the item is true of both metals and non-metals.
D. if the item is true of neither metals nor non-metals.

56. (2.10) Are good conductors of heat and electricity.

57. (2.10) Combine readily with elements of Group I of the periodic table.

58. (2.10) Many are gases or low-melting solids.

59. (2.10) The halogens are examples.

60. (2.10) Their oxides in water form basic solutions.

61. (2.10) Are frequently good electron acceptors or oxidizing agents.

62. (2.10) Are chemically inert and form no compounds.

63. (2.10) Combine chemically with oxygen to form oxides.

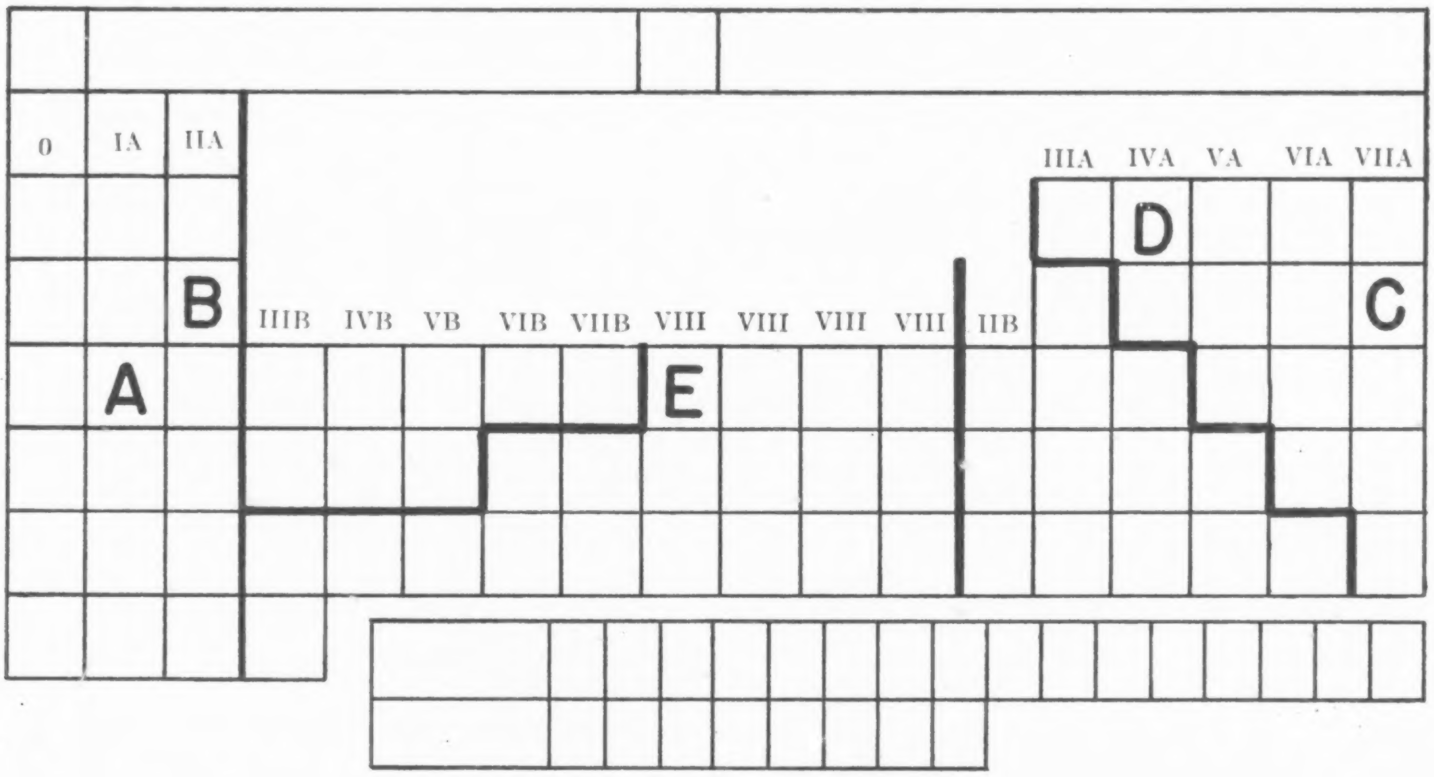
Items 64 - 75. The following diagram represents an outline of the periodic table. After the item number on the answer sheet, blacken the *one* lettered space which designates the position in the table to which the item correctly refers.

64. (2.10) The element in this position is most likely a non-metal.

65. (2.10) The positive *ion* of the element in this position has the electronic structure or configuration 2-8-8.

66. (2.10) One would expect to find in this position the element which forms most fuels.

67. (2.10) The element in this position, and others in the same group, have high melting points, tensile strength, and density, and are malleable and ductile.



68. (2.10) The element in this position floats in water and combines rapidly with it forming a strong base.

69. (2.10) Just below the element in this position is the element which occurs in most rocks.

70. (2.10) The hydrogen compounds of the element in this position, and of the elements above and below it, when dissolved in water have strong acidic properties.

71. (2.10) Elements in the group containing this element form positive ions which combine with chlorine ions, ion for ion.

72. (2.10) The element in this position forms compounds which, as a rule, do not conduct an electric current in aqueous solution.

73. (2.10) One of the elements in the group which includes this element is the most widely used metal.

74. (2.10) The positive ion of the element in this position has the electronic structure or configuration 2-8.

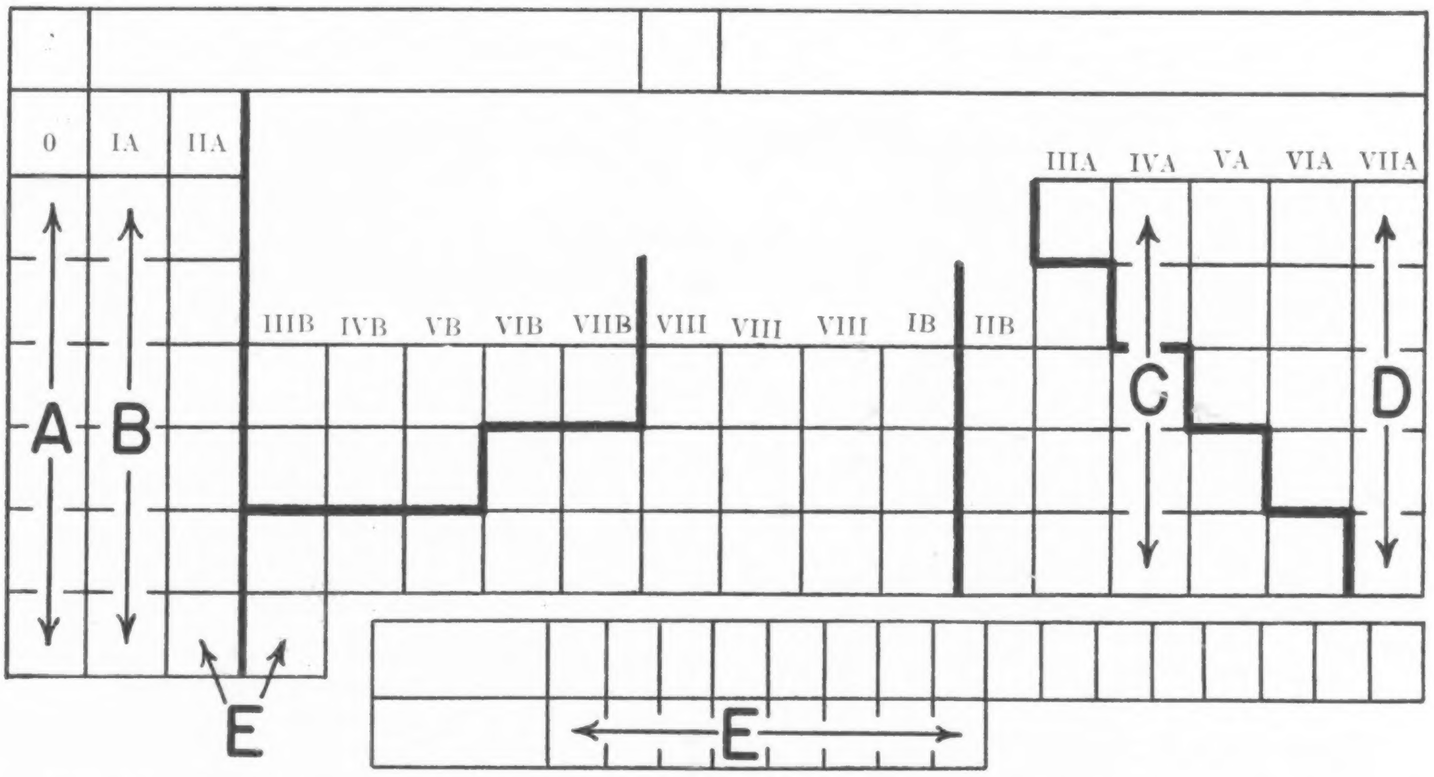
Items 75 - 86. The following diagram represents, in skeleton form, the periodic table. Certain columns of the table are labeled A, B, C, and D. The letter E designates the location of elements of atomic numbers 88-96. After the number on the answer sheet corresponding to that of each statement, blacken the one lettered space indicating the location in the table to which the statement correctly refers.

75. (2.10) Elements near the top of this column share electrons when forming compounds.

76. (2.10) With one exception, the outer shells of the atoms of these elements always contain eight electrons.

77. (2.10) All of the elements of this column are classified as metals.

78. (2.10) The great chemical activity of the element at the top of this column when reacting with metals is attributed to its relatively small atomic radius.



79. Most of the naturally occurring radioactive elements are found in this location.
(2.10)

80. Near the top of this column are elements which gain electrons most readily.
(2.10)

81. An element from this column is used in dirigibles because of its lightness and non-inflammability.
(2.10)

82. An element of this column is found in all organic compounds, while another element in the same column is found in combination in numerous rocks.
(2.10)

83. The halogens are located in this column.
(2.10)

84. The elements near the bottom of this column lose electrons most readily.
(2.10)

85. One of the elements in this column was discovered to be present in the atmosphere of the sun, before it was discovered on earth.
(2.10)

86. An element whose single outer electron is at the greatest distance from the nucleus of the atom is located at the bottom of this column.
(2.10)

Items 87 - 93 refer to part of the periodic table:

SERIES	0	I	II	III	IV	V	VI	VII	VIII
1		H							
2	He	Li	Be	B	C	N	O	F	
3	Ne	Na	Mg	Al	Si	P	S	Cl	
4	A	K	Ca	Sc	Ti	V	Cr	Mn	Fe Co Ni

For each item select from the key the group in which the element lies.

KEY

A. Group I. **B.** Group II. **C.** Group III.
D. Group IV. **E.** Group V.

87. The carbonate of this element is found in marine fossils.
(2.10)

88. An element forming compounds by gaining 2 electrons.
(2.10)

89. The most active non-metal listed.
(2.10)

90. The fused oxide of this element transmits ultra-violet.
(2.10)

91. An element forming compounds by losing 1 electron.
(2.10)

92. An element usually combustible but *not* in its purest form.
(2.10)

93. An oxide of this element is a well known laboratory catalyst.
(2.10)

94. Three elements belonging to group Ia have atomic numbers 11, 19, 55. The one true statement about this group is
(2.10)

A. the elements are inert.
B. the activity is unpredictable.
C. number eleven is the most active.
D. number nineteen is more active than number fifty-five.
E. number fifty-five is the most active.

Items 95 - 102 deleted.

Items 103 - 108 refer to the Periodic Table.

SERIES	GROUPS 0	1	2	3	4	5	6	7	8
0									
1	He	Li	Be	B	C	N	O	F	
2	Ne	Na	Mg	Al	Si	P	S	Cl	
3	A	K	Ca	Sc	Ti	V	Cr	Mn	Fe Co Ni
		Cu	Zn	Ga	Ge	As	Se	Br	
4	Kr	Rb	Sr	Yt	Zr	Cb	Mo	Ma	Ru Rh Pd
		Ag	Cd	In	Sn	Sb	Te	I	
5	Xe	Cs	Ba	La	Hf	Ta	W	Re	Os Ir Pt
		Au	Hg	Tl	Pb	Bi	Po		
6	Rn		Ra	Ac	Th	Pa	U		

For items 103 - 108 select from the key the principle which applies to each item.

KEY

- **A.** A group forming no compounds because their electron grouping is very stable.
- **B.** A group having two outer electrons.
- **C.** A regular increase in the number of valence electrons to a maximum in this group.
- **D.** All the elements in this group form compounds by losing one electron per atom.
- **E.** None of the above apply to this group.

103. Group 4. (2.10) **104.** Group 1. (2.10) **105.** Group 0. (2.10)

106. Group 8. (2.10) **107.** Group 2. (2.10) **108.** Group 7. (2.10)

Items 109 - 115 refer to the horizontal series in the Periodic Table. Select from the key the most appropriate description for each item.

KEY

- **A.** This member is a typical non-metal.
- **B.** This member is a typical base former and reducing agent.
- **C.** Decrease in metallic character.
- **D.** Increase in metallic character.
- **E.** Not descriptive of any of the above.

109. The element in series 2, group 1.
(2.10)

110. The element in series 1, group 7.
(2.10)

111. The element in series 2, group 4.
(2.10)

112. Proceeding from Bi to C vertically.
(2.10)

113. Proceeding from K to Ti.
(2.10)

114. Proceeding from S to Al.
(2.10)

115. Proceeding from P to Cl.
(2.10)

Items 116 - 122 concern elements in the Periodic Table. Select from the key the most appropriate response for each item.

KEY

- **A.** Outer shell contains eight electrons.
- **B.** A metal which will float on water.
- **C.** An oxidizing agent. **D.** A high specific gravity.
- **E.** Shares electrons and combines with itself.

116. Silicon. (2.10) **117.** Iodine. (2.10) **118.** Neon. (2.10)

119. Lithium. (2.10) **120.** Carbon. (2.10) **121.** Platinum. (2.10)

122. Manganese.
(2.10)

Items 123 - 126 are based on the following short periodic table which lists symbol of each element and its atomic number.

3 Li	4 Be	5 B	6 C	7 N	8 O	9 F	10 Ne
11 Na	12 Mg	13 Al	14 Si	15 P	16 S	17 Cl	18 A

123. Which of the following elements would tend most to
(2.10) take on electrons?

A. Li. **B.** Be. **C.** C. **D.** S. **E.** O.

124. Which of the following elements would most likely be
(2.10) a metal?

A. Mg. **B.** O. **C.** P. **D.** Be. **E.** Cl.

125. Which of the following is an inert gas?
(2.10)

A. Mg. **B.** Si. **C.** C. **D.** P. **E.** A.

126. The atoms of which of the following elements would
(2.10) you expect to lose electrons most readily?

A. Al. **B.** B. **C.** C. **D.** Si. **E.** N.

127. By means of the Periodic Table, identify the element
(2.10) described as follows: A certain element exercises only the valence +2 in compounds. The atomic weight of the element is greater than that of chromium but is less than that of silver. The element is

A. bromine. **B.** calcium. **C.** strontium.
D. rubidium. **E.** potassium.

128. By means of the Periodic Table, identify the element
(2.10) described as follows: A certain element may exercise either positive or negative valence, its principal valences ranging from +4 to —4. The atomic weight of the element is greater than that of fluorine and is less than that of calcium. The element is

A. argon. **B.** chlorine. **C.** potassium.
D. silicon. **E.** sulfur.

129. By means of the Periodic Table, deduce the valence of
(2.10) chromium in the compound $BaCrO_4$. The answer is

A. +6. **B.** —6. **C.** +7. **D.** +3. **E.** +2.

130. Select the statement or statements which can be cor-
(2.10) rectly deduced from the Periodic Table.

- a. It would be expected that calcium would combine with chlorine to form a compound, $CaCl_3$.
- b. The valence number of copper is practically always +2.
- c. There probably exists a compound PH_3.

The correct selection includes

A. only a. **B.** only b. **C.** only c.
D. only b and c. **E.** a, b, and c.

131. The alkali metals of group Ia, lithium, sodium, potas-
(2.20) sium, rubidium, and cesium are the most active metals. Cesium is the most active in the list because as one proceeds from lithium to cesium

- **A.** the atomic radius increases.
- **B.** the number of valence electrons increases.
- **C.** the metallic properties become less pronounced.
- **D.** the valence increases.
- **E.** the atomic weight decreases.

132. "The properties of the elements are periodic functions
(2.20) of their atomic weights" means that

A. in a given group certain properties recur at regular intervals as the atomic weight increases.
B. elements function periodically.
C. the atomic weights of the elements, plotted against their atomic numbers, give a wave-like curve.
D. with progressive increase in atomic weight of the elements, types of chemical behavior recur at regular intervals.
E. in a collection of elements picked at random, one element in eight will have a valency of one.

133. When ionization potential is plotted against atomic num-
(2.30) ber for each of the elements, a series of peaks occurs on the graph. If one of these peaks is occupied by helium, another peak could be predicted for

A. lithium. **B.** carbon. **C.** fluorine.
D. neon. **E.** tungsten.

134. When the atomic volume of the elements is plotted as
(2.30) a function of the atomic number of the elements, a series of maxima and minima appear on the graph. If the atomic volume of sodium represents one of the maxima, it could be predicted that one of the other maxima would be represented by the atomic volume of the element

A. magnesium. **B.** neon. **C.** chlorine.
D. potassium. **E.** plutonium.

135. In the family of alkali metals (Na, K, etc.), cesium is the
(2.40) most active. The best explanation of this is that

A. it has a greater attractive force for valence electrons than the others.
B. its atomic number is greater.
C. its valence electron has an orbit with a greater radius than the others.
D. its incomplete shell or energy level is closer to the nucleus.
E. it has more electrons in the outer orbit than the others.

136. Chlorine is a more active non-metal than is iodine. This
(2.40) is probably because

A. chlorine loses electrons more readily than does iodine.
B. the incomplete shell of electrons in the chlorine atom is closer to the nucleus than is the one in the iodine atom.
C. iodine adds electrons more readily than does chlorine.
D. the negative valence electron of the chlorine atom is farther away from the nucleus than is the one in the iodine atom.
E. chlorine is an oxidizing agent.

137. A. Since the composition of ammonia gas is NH_3, one
(3.00) might reasonably expect the existence of a compound PH_3.

B. Since the composition of sulfuric acid is H_2SO_4, one might reasonably expect the existence of a compound $HSeO_5$.

C. Since the composition of calcium chloride is $CaCl_2$, one might reasonably expect the existence of a compound Ra_2O_3.

Nitrogen and phosphorus are in group V of the Periodic Table, sulfur and selenium in group VI, and calcium and radium in group II.

Which one of the following choices names only the correct inference or inferences of those above?

A. A. **B.** B. **C.** C. **D.** A and B.
E. A and C.

138. Judging by the implications of the Periodic Table, one
(3.00) can validly infer that there might exist a compound with molecular composition

A. $MgCl_2$. **B.** HeO_2. **C.** Al_3Sn_2. **D.** CO_5.
E. CaF.

29. Mathematics Related to Physical Science

MATHEMATICS
RELATED TO PHYSICAL SCIENCE

1. (1.10) The capacity of a metal container used for measuring quantities of different kinds of grain is usually expressed in units of

A. mass. **B.** weight. **C.** density. **D.** volume.
E. specific gravity.

2. (1.10) The fundamental units of measure are

A. speed, time, and distance.
B. length, width, and area.
C. length, mass, and time.
D. area, heat, and volume.
E. millimeter, centimeter, and kilometer.

3. (1.10) In order to compute 0.25% of a number, the number must be multiplied by

A. 0.0025. **B.** 0.025. **C.** 0.25. **D.** 2.5. **E.** 25.

4. (1.10) Which one of these is a vector quantity?

A. 80 calories per gram. **B.** 10 lbs. per cubic foot.
C. W. 21° N. **D.** Uniform circular motion.
E. Speed.

5. (1.10) All of these are vector quantities *except*

A. velocity. **B.** uniform circular motion.
C. W. 27° N. **D.** $g = 32$ ft./sec.^{2}.
E. a force of 100 lbs.

6. (1.10) The usual definition of a radian is such that the radian

A. divides a circle into equal parts.
B. is smaller than a degree.
C. is π times the number of degrees in a circle.
D. subtends an arc as long as the radius.
E. is a measure of the length of arc of a circle.

7. (1.10) If the tangent of an angle is 3/4, its sine is

A. 1/2. **B.** 4/3. **C.** 5/4. **D.** 4/5. **E.** 3/5.

8. (1.10) In what quadrant is the angle −175°?

A. First quadrant. **B.** Second quadrant.
C. Third quadrant. **D.** Fourth quadrant.

9. (1.10) Which one of these is false?

A. $\sin 65° = \cos 25°$. **B.** $\tan 73° = \cot 17°$.
C. $\cot 45° = \tan 45°$. **D.** $\sec 90° = \csc 0°$.
E. None of these.

10. (1.10) If the tangent of a first quadrant angle is 3/4, its sine is

A. 1/2. **B.** 4/3. **C.** 5/4. **D.** 4/5. **E.** 3/5.

11. (1.10) Which one of these is the smallest quantity?

A. 3 mm. **B.** 0.4 cm. **C.** .005 m. **D.** 1/24 ft.
E. 1/5 in.

12. (1.10) Which one of these is *not* correct?

A. $\sin 165° = +\sin 15°$ **B.** $\sin 230° = +\sin 50°$.
C. $\cos 200° = -\cos 20°$. **D.** $\sin 310° = -\sin 50°$.
E. $\sec 100° = -\sec 80°$.

Items 13 - 23 contain pairs of statements which may be consistent or inconsistent with each other, and either one of the statements may be true or false. For each item select from the key the correct response.

KEY

A. Both statements true. **B.** Both statements false.
C. (I) true; (II) false. **D.** (I) false; (II) true.

13. (1.10) I. Count Rumford's conclusion that "heat is motion" is *not* valid today.
II. Heat is a form of molecular motion.

14. (1.10) I. The observation by Galileo that Venus showed phases like the moon helped support the heliocentric theory.
II. The heliocentric theory holds that the earth is one of several planets revolving around the sun.

15. (1.10) I. The period of time known as the Dark Ages was one of very little progress.
II. The Dark Ages was a time when observation and experimentation held sway over reasoning from authority.

16. (1.10) I. The cosecant is the reciprocal of the cosine.
II. The cosecant of an angle is equal to $\frac{1}{\text{cosine}}$.

17. (1.10) I. The ratio of the sides of a right triangle is independent of the size of the triangle.
II. The ratio of the sides of a right triangle depends only on the size of the angles.

18. (1.10) I. Work as defined in science equals force times distance.
II. Work is expressed at the time rate of using energy.

19. (1.10) I. The slope of a straight line is not constant.
II. At every point on the line the slope is different.

20. (1.10) I. Compressing air adiabatically causes no change in temperature.
II. No heat is added or subtracted during an adiabatic change.

21. (1.10) I. Carbon may have a positive or negative valence.
II. In compound formation carbon may lend or borrow electrons.

22. (1.10) I. When a star is moving away from or toward the earth there is a shift in its spectrum.
II. The apparent frequency of the light coming from the star to the earth is changed.

23. (1.10) I. The solar day is longer than the sidereal day.
II. The earth is moving in its orbit while turning on its axis.

24. (1.10) The usual definition of a radian shows that the radian

A. is a measure of the length of arc of a circle.
B. subtends an arc as long as the radius.
C. is π times the number of degrees in a circle.
D. divides a circle into six equal parts.
E. is a measure of linear distance around the circumference of a circle.

Items 25 - 28 involve trigonometric functions in various quadrants. For each item select from the key the quadrant in which the angle would lie.

KEY

A. Quadrant I. **B.** Quadrant II. **C.** Quadrant III.
D. Quadrant IV. **E.** Any quadrant.

25. (1.10) In what quadrant is the angle θ if its sine is negative and its cosine positive?

26. (1.10) In what quadrant is the angle $-115°$?

27. (1.10) In what quadrant is the angle θ if its cosecant is positive and cotangent negative?

28. (1.10) In what quadrant is the angle which has a cosine of $-\frac{1}{2}$ and a tangent which is positive?

29. (1.10) Sin 250° equals

A. sin 10°. **B.** —sin 10°. **C.** —sin 100°.
D. sin 80°. **E.** none of these.

30. (1.10) A liter is to a cubic centimeter as a meter is to a

A. centimeter. **B.** dekameter. **C.** millimeter.
D. decimeter. **E.** micron.

31. (1.10) When water is decomposed into its elements, the volume of hydrogen produced is twice as great as the volume of oxygen. The weight of hydrogen produced, compared to the weight of the oxygen, is

A. twice as much. **B.** half as much.
C. one-quarter as much. **D.** one-eighth as much.
E. one-sixteenth as much.

32. (1.10) Tan $-115°$ equals

A. tan 65°. **B.** —tan 25°. **C.** —tan 65°.
D. tan 25°. **E.** tan 115°.

33. (1.10) In what quadrant is an angle with a tangent which is negative and a sine which is negative?

A. I. **B.** II. **C.** III. **D.** IV.
E. There is no such angle.

34. (1.10) If the cosine of $60° = \frac{1}{2}$ what other angle (less than 360°) has the same answer?

A. 120°. **B.** 150°. **C.** 240°. **D.** 300°.
E. 330°.

35. (1.10) If the tangent of an angle is 3/4, its sine is

A. 3/5. **B.** 4/5. **C.** 4/3. **D.** 1/2. **E.** 1/5.

36. (1.10) Which one of the following fractions is the smallest?

A. 4/5. **B.** 7/9. **C.** 9/11. **D.** 10/13. **E.** 11/14.

37. (1.10) Some common metric measures of length are:

a. meter (m.). b. centimeter (cm.).
c. kilometer (km.). d. millimeter (mm.).

In increasing order of size, the correct order for listing these units is

A. d, b, a, c. **B.** b, a, d, c. **C.** d, c, b, a.
D. d, a, b, c. **E.** some order not listed here.

38. (1.10) When the cosine of an angle in the 4th quadrant is 4/5, the tangent of the same angle is

A. $-4/5$. **B.** $-3/4$. **C.** $-3/5$. **D.** 5/3.
E. none of these.

39. (1.10) Sin 260° equals

A. sin 10°. **B.** —sin 10°. **C.** —sin 100°.
D. sin 80°. **E.** none of these.

40. (1.10) One cubic inch is equivalent to approximately

A. .048 cubic centimeters. **B.** 2.54 cubic centimeters.
C. 6.5 cubic centimeters. **D.** 16 cubic centimeters.
E. 1000 cubic centimeters.

41. (1.10) Which one of these is a vector quantity?

A. W 30 degrees N. **B.** 10 lbs. per square inch.
C. 60 degrees Fahrenheit.
D. $5.40 per hundred pounds.
E. N wind of 35 miles per hour.

42. (1.21) The number of significant digits in 0.023040 is

A. 2. **B.** 3. **C.** 5. **D.** 6. **E.** 7.

43. (1.21) The number 2,467,543.2 rounded off to four significant digits becomes

A. 2,467,000.0. **B.** 2,468. **C.** 2,467.
D. 2,468,000. **E.** 2,468,000.0.

44. (1.21) The three edges of a rectangular solid are measured as 21.34 in., 8.27 in., and 25.0 in. The computed volume should be written with

A. four significant digits. **B.** three significant digits.
C. two significant digits. **D.** two decimal places.
E. one decimal place.

45. (1.21) Four approximate numbers, 1.6300, 0.1203, 7.12 and 8, are to be added. The best answer is

A. 16.8703. **B.** 16.870. **C.** 16.87. **D.** 16.9. **E.** 17.

46. (1.21) A length was measured as 49.13 cm. and a width as 0.97 cm. From the standpoint of significant figures, the most acceptable calculation and result for the area would be (assume no error in the mathematics)

A. $49.13 \times 0.97 = 47.6561$ cm.^{2}
B. $49.13 \times 0.97 = 47.66$ cm.^{2}
C. $49.1 \times 0.97 = 47.627$ cm.^{2}
D. $49 \times 0.97 = 47.53$ cm.^{2}
E. $49 \times 0.97 = 48$ cm.^{2}

47. (1.21) The diameter of a circle was measured as 8.3 cm. From the standpoint of significant figures, the most acceptable answer for the circumference of the circle would be (assume that no error exists in the mathematics)

A. $8.3 \times 3.1416 = 26.07528$.
B. $8.3 \times 3.1416 = 26.075$.
C. $8.3 \times 3.14 = 26.062$. **D.** $8.3 \times 3.1 = 25.73$.
E. $8.3 \times 3.1 = 26$.

For items 48 - 51 select from the key the phrase which would correctly fill the blank space.

KEY

A. directly proportional to
B. inversely proportional to
C. directly proportional to the square of
D. inversely proportional to the square of
E. inversely proportional to the square root of

48. (1.22a) The kinetic energy of a body is________the velocity.

49. (1.22a) The power lost as heat in long distance transmission of electric power is________the current.

50 (1.22a) The resistance of a piece of wire to the flow of electric current is________the diameter.

51. (1.22a) The velocity of sound is________the density of the medium carrying the sound.

For items 52 - 69 select from the key the response which will correctly fill the blank space in the statement of the item.

KEY

A. Directly proportional to
B. Inversely proportional to
C. Directly proportional to the square of
D. Inversely proportional to the square of
E. Independent of

52. (1.22a) When electrical power is supplied to the primary coil of a transformer, the current in the secondary coil is ________the voltage in the secondary coil.

53. (1.22a) In Kepler's Harmonic Law, $T^2 \alpha D^3$, the cube of the mean distance of a planet from the sun is________the period of revolution.

54. (1.22a) In electrostatics, the force of repulsion between like charges is________the distance between them.

55. (1.22a) At constant pressure, the volume of a perfect gas is ________the absolute temperature.

56. (1.22a) Wien's Law, $\lambda = K/T$, states that at the point of maximum radiation, the wave length is________the absolute temperature.

57. In the equation, $F = \frac{Mv^2}{r}$, for a given mass at a fixed radius, F is________V.

58. (1.22a) The way the force of attraction between unlike magnet poles varies with the distance between them.

59. (1.22a) The way n varies with λ in the wave equation $v = n\lambda$.

60. (1.22a) The way the force of attraction between the moon and the earth varies with the distance between them.

61. (1.22a) The way the heat developed in a given wire having electrical resistance varies with the quantity of current passing through it.

62. (1.22a) At constant temperature, the density of a gas is________the pressure.

63. (1.22a) Current through a circuit is________the resistance.

64. (1.22a) The force of gravity is________the distance from the center of the earth.

65. (1.22a) The pressure at any depth under a liquid is________the shape of the container.

66. (1.22a) In the equation $P/T = k$, P is________T.

67. (1.22a) In electrostatics, the force of repulsion between like charges is________the distance between them.

68. (1.22a) In Kepler's Law the cubes of the mean distance of the planets from the sun are________the periods of revolution.

69. (1.22a) Electric power, watts = VI. If a transformer was operating at 500 watts, then V is________.

For items 70 - 75 select from the key the phrase which would correctly fill the blank space.

KEY

A. directly proportional to
B. inversely proportional to
C. directly proportional to the square of
D. inversely proportional to the square of
E. inversely proportional to the square root of

70. (1.22a) The frequency of light is________the wave length.

71. (1.22a) The power lost as heat in the long distance transmission of electric power is________the current.

72. (1.22a) The velocity of sound is________the density of the medium.

73. (1.22a) The resistance of a piece of wire is________the diameter.

74. (1.22a) The acceleration given a body is________the force applied.

75. (1.22a) The kinetic energy of a body is________the velocity.

76. (1.23) $F = \frac{kMm}{d^2}$ is an expression of

A. a natural law. **B.** an hypothesis. **C.** a theory.
D. an assumption.

77. (1.23) Physical chemistry is

A. chemistry applied to athletics.
B. physics and mathematics applied to chemistry.
C. chemistry applied to physiology.
D. chemistry applied to geology.
E. inorganic chemistry.

78. (1.30) The metric system is superior to the English system of measurement in that

A. measurements can be made more accurately with it.
B. 1000 cubic centimeters of water at 40°C. weighs exactly 1000 grams.
C. multiples of the fundamental units are related by the factor 10 or a multiple of ten.
D. it includes familiar units of time.
E. one can get more kilometers per gallon of gasoline than miles per gallon with any automobile.

79. (1.30) The chief advantage of writing numbers in denary notation is to

A. increase accuracy of calculations.
B. make use of symbols rather than numbers.
C. be able to solve problems in astronomy.
D. promote the use of the metric system.
E. simplify the writing of very large or very small numbers.

80. The relationship between force, mass, and acceleration
(1.30) may be written in three ways

$$F \propto ma \qquad F = kma \qquad F = ma$$

This is because

A. the relationship between a given force, mass and acceleration varies under different conditions.

B. like energy, force is an abstract concept and thus must sometimes be determined by the use of a constant.

C. the acceleration depends upon the gravitational attraction at the place in question.

D. mass is not the same thing as weight.

E. the equality but not the proportionality of a formula is dependent upon the system of units employed.

81. Many physical quantities vary inversely with the square
(1.30) of another quantity such as distance. Variations like this are frequently called inverse square laws. Which one of the following does *not* follow an inverse square law?

A. The force of gravity.

B. The force of attraction between unlike static charges.

C. The universal law of gravitation.

D. The intensity of illumination on a given surface.

E. The centripetal force.

82. All of these show inverse proportionality *except*
(2.10)

A. $\frac{V}{T} = k$. **B.** $P = \frac{k}{V}$.

C. V (constant) $= n\lambda$. **D.** $\frac{1}{y} \propto x$.

E. $\lambda T = k$.

83. A student took data on the length of a spring with
(2.10) various weights attached. He plotted W on the horizontal axis and L on the vertical axis. His report gave the equation of the line as $L = 2W + 5$. The slope of the line was

A. ½. **B.** 1. **C.** 2. **D.** 5.

E. none of these answers.

84. In item 83, the line crosses the vertical axis at
(2.10)

A. 0. **B.** 1. **C.** 2.5. **D.** 2. **E.** 5.

85. When an object is placed 4 cm. in front of a converg-
(2.10) ing lens with a focal length of 5 cm., the image distance is

A. 1 cm. **B.** 20 cm.

C. –5 cm. **D.** –20 cm. $\frac{1}{p} + \frac{1}{q} = \frac{1}{f}$

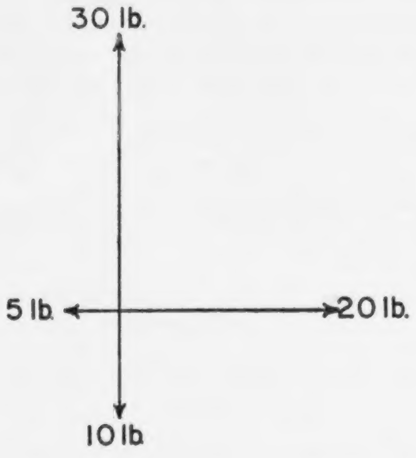
E. none of these answers.

86. If the hypotenuse of a right triangle is 29 inches and
(3.00) one leg is 20 inches long, the length of the other leg is

A. 35.2 inches. **B.** 5.0 inches. **C.** 18.5 inches.

D. 9.0 inches. **E.** none of these answers.

87. In the diagram, the value of the sum of the vectors is
(2.10)



A. 25 lb. **B.** 35 lb. **C.** 47 lb. **D.** 65 lb.

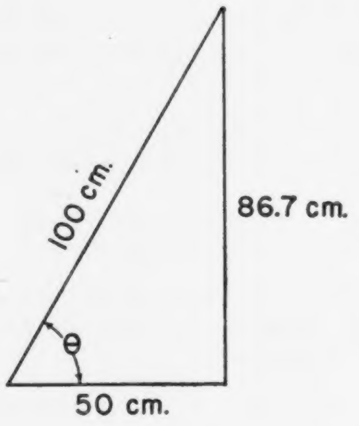
E. 15 lb.

88. In item 87, the direction of the resultant is
(2.10)

A. north. **B.** east. **C.** southwest. **D.** southeast.

E. none of these answers.

89. Referring to the diagram (not drawn to scale) which
(2.10) one of these is false?



A. sec $\theta = \frac{1}{.5}$.

B. $\sin^2 \theta + \cos^2 \theta = 1$.

C. cos θ is smaller than sin θ.

D. tan θ = sin θ/cos θ.

E. cot θ is greater than 1.

90. Water has a density of 62.4 lbs. per cubic foot. If the
(2.10) specific gravity of a piece of cork is .25, a cubic foot of cork weighs

A. 15.6 lbs. **B.** 46.8 lbs. **C.** 62.15 lbs. **D.** 78 lbs.

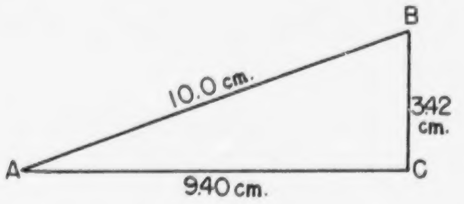
E. more data is required to answer this item.

91. A red corpuscle is 7.5×10^{-4} cms. in diameter.
(2.10) A sheet of paper is 8.0×10^{-3} cms. in thickness.

Approximately how many times thicker is the paper than the diameter of a red corpuscle?

A. 11. **B.** 1.1. **C.** .070. **D.** 110. **E.** 9.0.

92. (2.10) In the right triangle (not drawn to scale), if the length of the sides are in cm. as shown, the sine of the angle B is



A. 2.80. **B.** .342. **C.** .0106. **D.** .940.
E. none of these.

93. (210) Which one of these statements is true of the sine curve given by the equation $y = 2 \sin 3x$?

- **A.** The maximum displacement of the wave form is 1.
- **B.** The amplitude of the wave is 3.
- **C.** The wave length is 360°.
- **D.** The values of the function repeat themselves periodically.
- **E.** The period is the distance between consecutive points at which the curve crosses the horizontal axis.

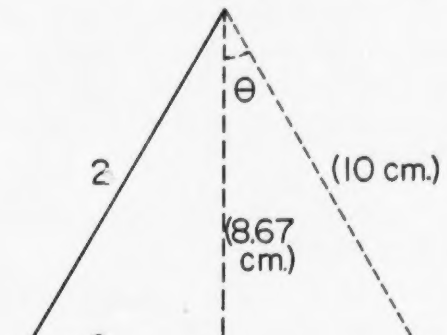
94. (2.10) A correct transposed expression for the equation $\frac{1}{f} = \frac{1}{p} + \frac{1}{q}$ is

A. $\frac{1}{f} = \frac{q - p}{pq}$. **B.** $f(q + p) = pq$.
C. $f = \frac{q + p}{pq}$. **D.** $f = p + q$.
E. $\frac{1}{f} = \frac{q + q}{pp}$.

95. (2.10) In the formula $\frac{A_1}{A_2} = \frac{(B_2)^2}{(B_1)^2}$

- **A.** A varies directly as B.
- **B.** A varies inversely as the square of B.
- **C.** A varies directly as the square of B.
- **D.** A varies inversely as B.
- **E.** none of the above is correct.

Items 96 - 98 refer to the diagram of an equilateral triangle divided into two triangles by dropping a perpendicular.



96. (2.10) The tangent of the 60° angle in the triangle at the left in the diagram is

- **A.** ½.
- **B.** $\sqrt{3}$.
- **C.** $\frac{2\sqrt{3}}{3}$.
- **D.** $\frac{\sqrt{3}}{3}$.
- **E.** none of these.

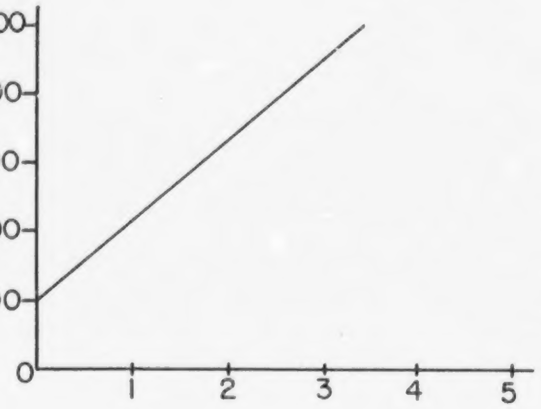
97. (2.10) The cosine of the angle θ in the triangle at the right in the diagram is

- **A.** ½.
- **B.** 1.15.
- **C.** .867.
- **D.** 2.
- **E.** none of these.

98. (2.10) The cosecant of θ is

- **A.** ½.
- **B.** 1.73.
- **C.** 1.15.
- **D.** .57.
- **E.** none of these.

Items 99-101. Use the data of the accompanying graph and key:



KEY

A. 1. **B.** 2. **C.** 100. **D.** 200. **E.** 300.

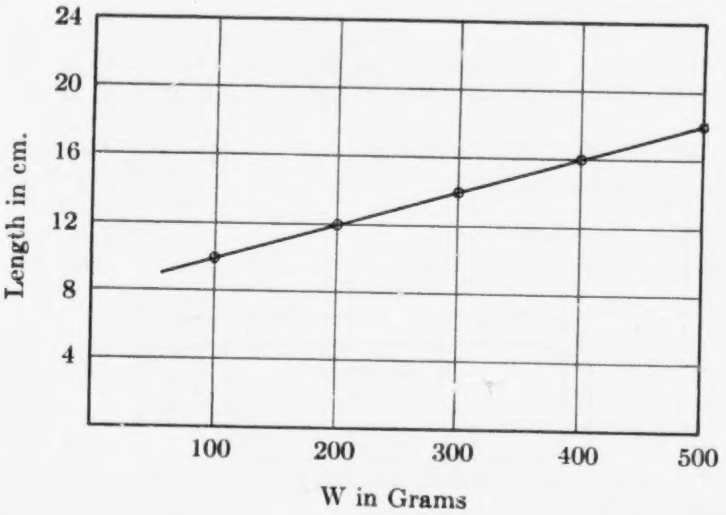
99. (2.10) What is the value of the slope of the line?

100. (2.10) What is the value of "b"?

101. (2.10) When "Y" is 200, what is the value of "X"?

Items 102 - 103 are to be answered from this data showing the length of a spring with various weights attached and represented by the graph.

L (cm.)	10	12	14	16	18
W (grams)	100	200	300	400	500



102. The slope of the line is
(2.10)

A. 10. **B.** .025. **C.** .1. **D.** 50.
E. none of these.

103. The equation of the line is
(2.10)

A. $L = .025W + 10$. **B.** $L = .1W + 8$.
C. $L = .02W + 8$. **D.** $L = .10W + 10$.
E. L = none of these.

104. The relationship $\frac{R}{M}$ = "K" (where "K" is a constant),
(2.10) means that

A. when "R" becomes larger, "K" becomes larger.
B. when "R" becomes larger, "K" becomes smaller.
C. when "M" becomes larger, "K" becomes larger.
D. when "R" becomes larger, "M" becomes smaller.
E. when "R" becomes larger, "M" becomes larger.

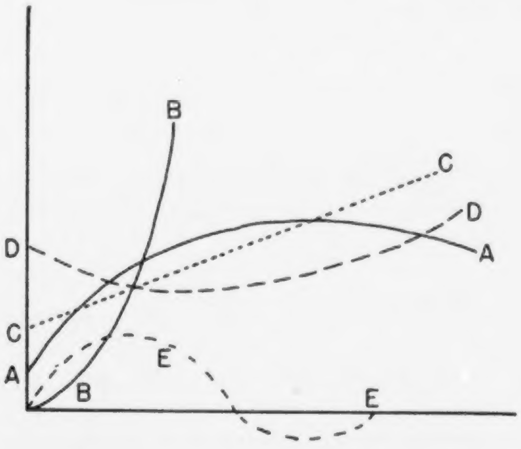
105. The general formula $x = p\frac{Y_1 \quad Y_2}{Z^2}$ represents all *except*
(2.10)

A. The Law of Gravitation.
B. Coulomb's Law of Electrostatic Repulsion.
C. The Law of Magnetic Attraction.
D. The Inverse Square Law of Intensity of Light.

106. If two variables vary in such a way that their product
(2.10) is always a constant, the one is said to be inversely proportional to the other. Which of the following is *not* in agreement with this statement?

A. $PV = k$. **B.** $V = \frac{k}{p}$. **C.** $PV = \frac{k}{2}$.
D. $P = \frac{k}{V}$. **E.** $\frac{P}{V} = k$.

For items 107 - 109 indicate which curve in the following diagram would give the closest approximation to the data.



107.
(2.10)

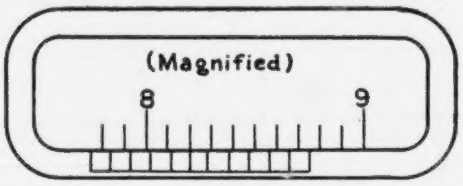
Vertical–Horsepower required	15	12	11	12	13	14	16.
Horizontal–Air speed in mph	45	55	65	75	85	95	105.

108.
(2.10)

Vertical–Distance of free fall	16	64	144	256
Horizontal–Time	1	2	3	4

109.
(2.10)

Vertical–Fahrenheit	32	140	212
Horizontal–Centigrade	0	60	100



110. The diagram represents a magnified view of a vernier
(2.10) scale with the numbers indicating whole centimeters. The setting shown can be read with significant figures only as

A. 7.75. **B.** 8.65. **C.** 8.25. **D.** 7.65.
E. 8.20.

111. If 12 cu. ft. of oxygen at 1 atmospheric pressure were
(2.10) compressed so slowly that the temperature remained constant, the relationship between the pressure and the volume as shown in the table would be

A. $V/P = 12$.
B. $V = 4/P$.
C. $V = 12/P$.
D. $P/V = T$.
E. $V = P/12$.

TABLE

P in atmospheres	1	2	3	4
V in cubic feet	12	6	4	3

112. If the oxygen were allowed to escape suddenly (in the
(1.30) preceding problem),

A. the temperature would not change since the gas was compressed without change in temperature.
B. work would be done in pushing back the air boundaries.
C. the temperature would rise.
D. isothermal expansion would take place.
E. the average kinetic energy of the molecules of oxygen would increase.

113. The equation that will plot as a straight line on a graph
(2.10) is

A. $d = 16t^2$. **B.** $T = k\sqrt{L}$. ← $T = K\sqrt{L}$.
C. $A = \pi r^2$. **D.** $I = \frac{k}{d^2}$. ← $I = \frac{K}{d^2}$.
E. $C = 2\pi R$.

114. In the equation, $F = ma$, a definite relationship is ex-
(2.10) pressed symbolically between force, mass, and acceleration. From this equation it follows that if force is increased, then

A. mass must also increase if acceleration remains unchanged.
B. both mass and acceleration must increase.
C. mass must increase while acceleration must decrease.
D. mass and acceleration must both decrease.
E. acceleration must decrease if mass remains unchanged.

115. If $\pi = c/d$, then which one of the following relation-
(2.10) ships does not follow?

A. $\pi \times d = c$. **B.** $c/\pi = d$.
C. $(\pi \times d)/c = 1$. **D.** $c - (\pi \times d) = 0$.
E. $\pi \times c = d$.

116. Given the atomic weights: nitrogen = 14, oxygen = 16,
(2.10) hydrogen = 1. The formula weight of NH_4OH is

A. 35. **B.** 83. **C.** 34. **D.** 77.
E. none of these.

117. The frequency of a vibrating string varies with the
(2.10) square root of the applied force, indirectly with the square root of the mass per unit length, and inversely with the length of the string. This variation is shown by

A. $n \propto \frac{F^2}{Lm^2}$.

B. $n \propto \frac{F}{m}\sqrt{\frac{1}{L}}$.

C. $n \propto \frac{1}{L}\sqrt{\frac{m}{F}}$.

D. $n \propto \frac{1}{L}\sqrt{\frac{F}{m}}$.

E. none of these.

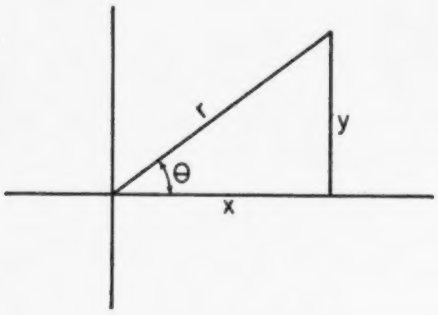
n	frequency
F	force
m	mass per unit length
L	length

Item 118 deleted.

119. (2.10) An identity is a statement of equality which is true for all values of the variables. In proving the identity

$$\cos\theta \cdot \tan\theta = \sin\theta,$$

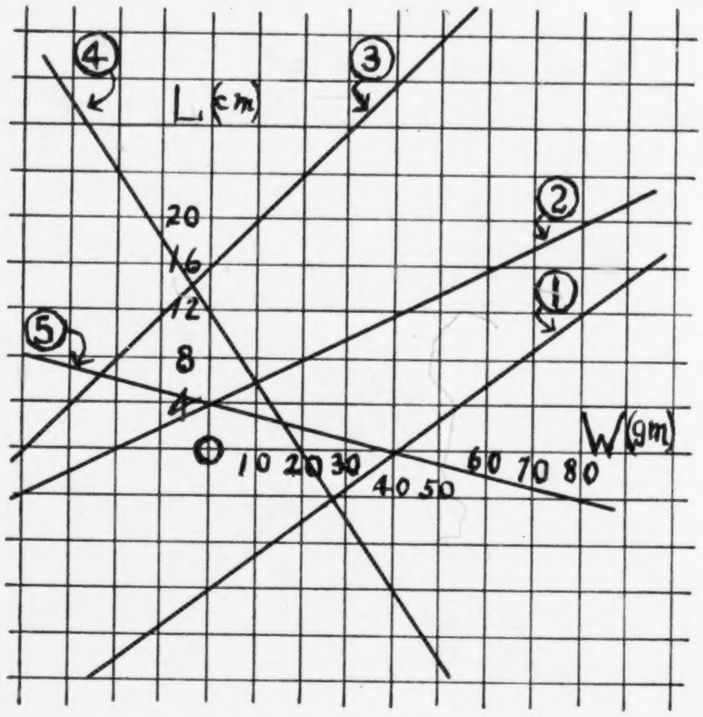
which one of the following is correct? x and y are the variables.



A. $\frac{r}{x}\cdot\frac{x}{y} = \frac{r}{y}$. **B.** $\frac{x}{r}\cdot\frac{y}{x} = \frac{y}{r}$. **C.** $\frac{y}{r}\cdot\frac{r}{x} = \frac{y}{x}$.

D. $\frac{\frac{x}{r}}{\frac{y}{x}} = \frac{y}{r}$. **E.** None of the above.

Items 120 - 123 refer to the following data and diagram. A spring is loaded with weights and allowed to stretch. The resulting lengths L (in cm.) for weights W (in grams) are indicated in the following table.



120. (2.10) In the figure, the line which represents the graph of this data is

A. line #1. **B.** line #2. **C.** line #3.
D. line #4. **E.** line #5.

121. (2.10) The original length of the spring before weights were added was

A. 1 cm. **B.** 2 cm. **C.** 4 cm. **D.** 6 cm.
E. 8 cm.

122. (2.10) If the spring continues to stretch according to the data given, what will its length be when W = 80 gm.?

A. 14 cm. **B.** 16 cm. **C.** 18 cm.
D. 20 cm. **E.** 25 cm.

123. (2.10) The slope of the line #3 is

A. 0. **B.** 1/10. **C.** 2/10. **D.** 4/10. **E.** 2.

124. (2.10) If $V = r^2h/3$ and if r is doubled and h is halved, then V is multiplied by

A. ½. **B.** 2. **C.** 3. **D.** 4. **E.** ⅛.

125. (2.10) In the equation $V = n\lambda$, n is

A. directly proportional to λ.

B. inversely proportional to λ.

C. directly proportional to the square of λ.

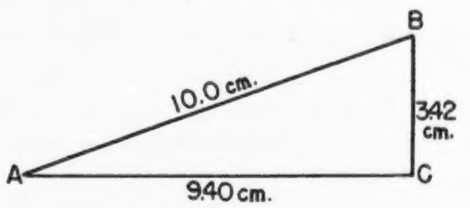
D. inversely proportional to the square of λ.

E. independent of λ.

126. (2.10) The equation that will plot as a straight line on a graph is

A. $d = 16t^2$. **B.** $T = K\sqrt{L}$. **C.** $A = \pi r^2$.
D. $1 = \frac{K}{d^2}$. **E.** $C = 2\pi r$.

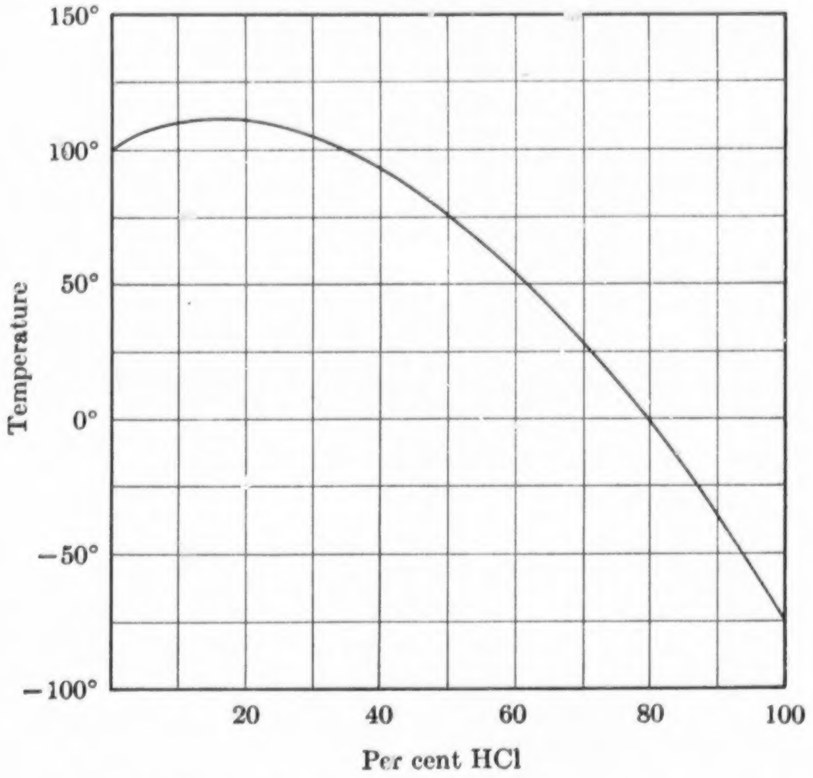
127. (2.10) In the right triangle (not drawn to scale), if the lengths of the sides are in cm. as shown, the sine of the angle B is



A. 280. **B.** .342. **C.** .0106. **D.** .940
E. none of these.

Items 128 - 133 refer to the graph showing the variation in the boiling point of a solution containing various per cents of hydrogen chloride at standard atmospheric pressure.

Boiling-points of Hydrochloric Acid Solutions
Under Atmospheric Pressure



For each of the following items, select the correct response from this key.

KEY

A. The statement is true according to the reading of the graph.
B. The statement is false according to the reading of the graph.
C. The statement may be inferred as true although not specifically answered by the graph.
D. The statement cannot be answered without additional information.

128. When the percent of HCl present in the solution is 50%, the boiling point is about 62°C.
(2.10)

129. As the concentration increases from 0% to 100%, the boiling point continually decreases.
(2.10)

130. When the concentration reaches 80%, the solution would freeze.
(2.10)

131. It is possible for two different concentrations in per cent to have the same boiling point.
(2.10)

132. Changing the atmospheric pressure would shift the maximum boiling point to the left on the per cent scale.
(2.10)

133. At approximately 110°C., the per cent of concentration is 20%.
(2.10)

Items 134 - 136 refer to the following equations for sine curves representing waves in the same medium as typified by the general form y = a sine bx.

KEY

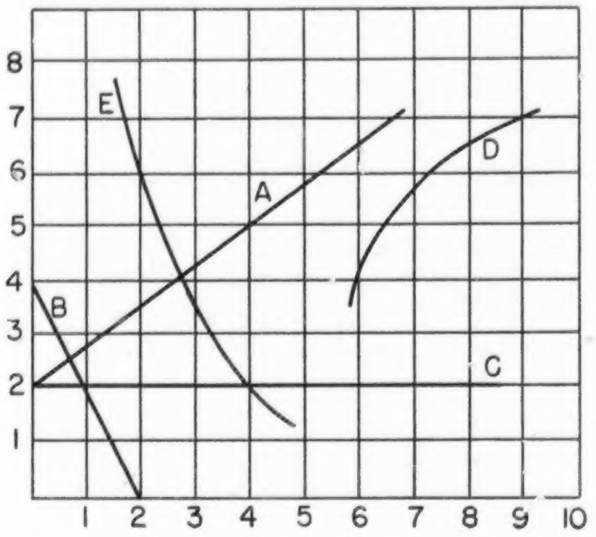
A. $y = 2 \sin \frac{1}{2} x$. **B.** $y = \sin 2x$.
C. $y = 4 \sin x$. **D.** $y = \frac{1}{2} \sin 4x$.
E. $y = 2 \sin 2x$.

134. The equation with the shortest period.
(2.10)

135. The equation with the smallest amplitude.
(2.10)

136. The equation with the greatest numerical wave length.
(2.10)

Items 137 - 140 refer to the following diagram.



For items 137 - 140 select from the key the lettered graph which describes the item.

KEY

A. A. **B.** B. **C.** C. **D.** D. **E.** E.

137. A graph representing the equation $y = \frac{3}{4}x + 2$.
(2.10)

138. A graph of the type which one would obtain for the increase in elongation of a spring with increased loads (not beyond the elastic limits).
(2.10)

139. A graph of the type obtained for Boyle's Law (pv = k).
(2.10)

140. A graph of a linear equation with a negative slope.
(2.10)

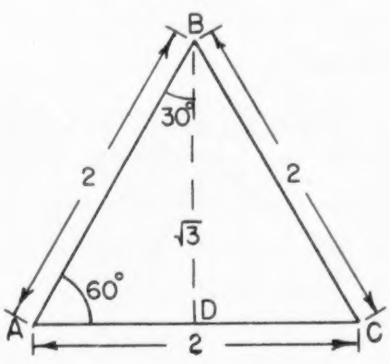
141. In five years a man's weight increased from 120 to 180 pounds. The per cent of increase in weight was
(2.10)

A. 150%. **B.** 66⅔%. **C.** 40%. **D.** 33⅓%.
E. none of these.

142. The solution for P′ in the following equation $\frac{P}{V} = \frac{P'}{V'}$ is
(2.10)

A. $\frac{V}{PV'}$. **B.** $\frac{PV}{V'}$. **C.** $\frac{VV'}{P}$. **D.** $\frac{PV'}{P'}$.
E. none of these.

Items 143 - 146 refer to the following diagram.



143. The cosine of 30° equals
(2.10)

A. $2\sqrt{3}$. **B.** ½. **C.** $\sqrt{3/2}$. **D.** $2/\sqrt{3}$.
E. none of these.

144. The tangent of 60° equals
(2.10)

A. 2/1. **B.** $\sqrt{3/2}$. **C.** $2/\sqrt{3}$. **D.** ½.
E. none of these.

145. The vertical component of a force of 100 lbs. acting at
(2.10) 30° with the horizontal is

A. $100/\sqrt{3}$. **B.** $100/\sqrt{2}$. **C.** 100(½).
D. $100\sqrt{2}$. **E.** none of these.

146. Select the one of the following which is a vector
(2.10) quantity.

A. W. 29° S. **B.** 5 gm./cm.^{3}.
C. A mass of 50 lbs. **D.** 25 mi./hr. S.
E. 10° below zero.

147. Which one of the following functions when plotted
(2.10) graphically should produce a "curve" of some kind other than a straight line?

A. $C = 2\pi r$. **B.** $d = ½ at^2$. **C.** $V = kT$.
D. $F = 9/5\ c + 32$. **E.** $L = .04W - 3$.

148. If X_1 and X_2 represent the parallaxes of two stars at
(2.10) distances d_1 and d_2 respectively, which of the following expressions correctly indicates the relation that exists between the parallax and the distance?

A. $\frac{d_1}{d_2} = \frac{X_1}{X_2}$. **B.** $\frac{d_2}{d_1} = \frac{X_2}{X_1}$. **C.** $d_1X_2 = d_2X_1$.
D. $\frac{d_2}{d_1} = \frac{X_1}{X_2}$. **E.** $d_2 = \frac{d_1X_2}{X_1}$.

149. In any equation of the type $y = kx$, where in solving
(2.10) for y one can insert various values of x, but k always remains the same in dealing with a particular functional relationship, k is

A. an exponent. **B.** a functional number.
C. a direct ratio. **D.** a proportionality constant.
E. a denary number.

150. Assuming that the following observations obey the gen-
(2.10) eral gas law, $P = \frac{kT}{V}$

P	1	2.4	5.6	8
V	200	100	50	40
T	150	180	210	240

The value of k in the above equation is

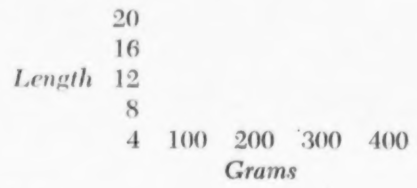
A. 1. **B.** 4/3. **C.** 2. **D.** 3/4. **E.** 3/2.

151. A length was measured as 49.13 cm. and a width as
(2.10) .97 cm. From the standpoint of significant figures, the most acceptable calculation and result for the area would be (assume no error in the mathematics)

A.	49.13 × .97	47.6761 cm.^{2}.
B.	49.13 × .97	47.66 cm.^{2}.
C.	49.1 × .97	47.627 cm.^{2}.
D.	49 × .97	48 cm.^{2}.

Items 152 - 153 are to be answered from this data showing the length of a spring with various weights attached and represented by the graph

L (cm.)	10	12	14	16	18
W (grams)	100	200	300	400	500



152. The slope of the line is
(2.10)

A. 10. **B.** .025. **C.** 1. **D.** 50. **E.** none of these.

153. The equation of the line is
(2.10)

A. $L = .025W + 10$. **B.** $L = .1W + 8$.
C. $L = .02W + 8$. **D.** $L = .10W + 10$.
E. L = none of these.

154. Assume that $L = \frac{gt^2}{4\pi^2}$ and that $L = 81$. If (L) changes
(2.10) to 9, (t) is reduced to

A. 1/9 its original value. **B.** ⅓ its original value.
C. ½ its original value. **D.** ¼ its original value.
E. none of these.

Items 155 - 158 use this section of the table of trigonometric functions.

ANGLE	SIN	COS	TAN
5°	.0872	.9962	.0875
6°	.1045	.9945	.1051
7°	.1219	.9925	.1228
20°	.3420	.9397	.3640
21°	.3584	.9336	.3839
22°	.3746	.9272	.4040
23°	.3907	.9205	.4245
67°	.9205	.3907	2.3559

155. Cos 70° equals
(2.10)

A. .9397. **B.** —.9397. **C.** .3420. **D.** —.3420.
E. .3640.

156. Cos 6°15′ equals
(2.10)

A. .9950. **B.** .9930. **C.** .9920. **D.** .9940.
E. none of these.

157. Tan 20.2° equals
(2.10)

A. .3680. **B.** .3879. **C.** .3660. **D.** .3799.
E. .3819.

158. The angle whose sine is .3786 (to the nearest minute)
(2.10) equals

A. 22°25′. **B.** 23°25′. **C.** 23°15′.
D. 22°15′. **E.** 22°4′.

159. In which of the following functional relationships will
(2.10) doubling the value of B produce the greatest change in A? Assume a constant, k, in all cases.

A. A varies directly as the square root of B.
B. A varies directly as the square of B.
C. A varies inversely as the square root of B.
D. A varies directly as B.
E. A varies inversely as B.

160. (2.10) The volume of 50 grams of sulfuric acid, specific gravity, 1.86, is

A. 83 ml. **B.** 1.86 times the molecular weight.
C. 26.9 ml. **D.** 26.9 g. **E.** none of these values.

161. (2.10) A gas occupies 3 liters at S.T.P. Its volume at +567°C. and at 380 mm. pressure will be

A. 18 liters. **B.** 3 liters. **C.** 1.5 liters.
D. 4.5 liters. **E.** none of these answers.

162. (2.20) An electric spark is passed through a mixture containing 16 grams of oxygen gas and 4 grams of hydrogen gas. After the explosion, there is in the container

A. 16 grams of water and 4 grams of hydrogen.
B. 8 grams of water and 12 grams of oxygen.
C. 6 grams of water and 14 grams of oxygen.
D. 20 grams of water.
E. 18 grams of water and 2 grams of hydrogen.

163. (2.20) In the formation of CaO, the relative combining weights are 5 gm. of Ca to 2 gm. of O. If 10 gm. of Ca and 6 gm. of O are taken for the experiment,

A. no reaction should occur.
B. the per cent of oxygen in the CaO would be greater.
C. CaO_2 should be formed.
D. some oxygen is left after CaO is formed.
E. the extra oxygen acts as a catalyst.

164. (3.00) A train, moving at a constant speed, runs x miles in y hours. Then the time, in hours required for the train to run 1 mile, is

A. xy. **B.** y/x. **C.** x/y. **D.** x + y/xy.
E. xy/x + y.

165. (3.00) Block A has a specific gravity of .75 and a weight of 20 grams. When floating in water this block A will displace

A. 10 g of water. **B.** 20 g of water.
C. 30 g of water. **D.** 40 g of water.
E. the displacement cannot be determined with the information available.

166. (3.00) A stick 10 feet long casts a shadow 4 feet long. At the same time a shadow 400 feet long is cast by a cliff. The height of the cliff in feet is

A. 2040. **B.** 160. **C.** 543. **D.** 600.
E. 1000.

167. (3.00) A small solid steel ball is placed in a tall glass containing a large amount of mercury. Then a quantity of water is poured on top. Which one of the following is a correct conclusion? Sp. gr. mercury = 13.56.
Sp. gr. steel = 7.9.

A. The ball will rise to the top of the mercury and then the mercury and water will exchange positions.
B. The ball will float on the mercury and rise slightly when the water is added.
C. The mercury will float on top of the water.
D. The ball will sink to the bottom of the container.
E. Adding the water makes the ball sink more deeply in the mercury.

168. (3.00) In an experiment on the synthesis of water by weight, a quantity of copper oxide was heated in a stream of hydrogen and the water product of the reaction collected by a tube of calcium chloride which readily absorbs water. The following data was collected:

Loss in weight of the CuO	2.4 gm.
Gain in weight of the $CaCl_2$	2.7 gm.

The weight of hydrogen involved was

A. .3 gm. **B.** 2.4 gm. **C.** 2.7 gm. **D.** 5.1 gm.
E. impossible to calculate.

169. (3.10) A hydraulic press has one piston 2 in. and the other 8 in. in radius. If a force of 100 lb. is applied to the smaller piston, the force exerted on the large piston will be

A. 6¼ lb. **B.** 25 lb. **C.** 100 lb. **D.** 400 lb.
E. 1600 lb.

170. (3.00) About how many grams of glucose are formed in the process of photosynthesis if 2,031,000 calories of solar energy are absorbed? The equation for the photosynthesis reaction is as follows:

$$6\,CO_2 + 6\,H_2O + 677{,}000 \text{ calories} \rightarrow \underset{\text{glucose}}{C_6H_{12}O_6} + 6\,O_2.$$

A. 180. **B.** 90. **C.** 540. **D.** 360. **E.** 720.

For items 171 - 173 evaluate the items according to the key.

KEY

A. Doubling the first will double the second.
B. Doubling the first will halve the second.
C. Doubling the first will multiply the second by four.
D. Doubling the first will reduce the second to one-fourth its original value.
E. Doubling the first will change the second in some way other than one of the above four, or leave it unchanged.

171. (3.00) A 30° angle of a right triangle—The other acute angle.

172. (3.00) Distance above sea level—Density of the air.

173. (3.00) The speed with which a baseball thrown horizontally leaves the thrower's arm—The time elapsing before the ball strikes the ground.

Items 174 - 176 refer to the following data. The atomic weight of silver has been determined accurately against oxygen and found to be 107.880. (It is to be assumed that no other atomic weights are known.) One method for the determination of the atomic weight of sulfur involves the removal of sulfur from silver sulfide by heating the silver sulfide in a stream of hydrogen. In one such determination, the following data were obtained:

Weight Ag_2S	13.27 gm.
Loss in weight Ag_2S	3.04 gm.

174. (3.00) In this experiment, the weight of silver involved was

A. 13.27 gm. **B.** 3.04 gm. **C.** 10.23 gm.
D. 16.31 gm. **E.** impossible to calculate.

175. (3.00) Which one of the following proportions would be most useful in calculating the atomic weight of sulfur?

A. $\frac{3.04}{13.27} = \frac{\text{A.W. (S)}}{\text{M.W. (}Ag_2S\text{)}}$. **B.** $\frac{10.23}{13.27} = \frac{\text{A.W. (S)}}{\text{M.W. (}Ag_2S\text{)}}$

C. $\frac{10.23}{13.27} = \frac{\text{A.W. (Ag)}}{\text{M.W. (}Ag_2S\text{)}}$. **D.** $\frac{3.04}{10.23} = \frac{\text{A.W. (S)}}{\text{A.W. (Ag)}}$

E. $\frac{10.23}{3.04} = \frac{\text{A.W. (S)}}{\text{A.W. (Ag)}}$.

176. In this experiment, the amount of hydrogen involved was
(3.00)

A. 3.04 gm. **B.** 0.19 gm. **C.** 3.23 gm.
D. 10.23 gm.
E. impossible to calculate from the data given.

177. A compound has 40% carbon, 6.6% hydrogen, and 53.3% oxygen. The simplest formula the compound could have is
(3.00)

A. CHO. **B.** $C_2H_4O_2$. $H = 1$
C. C_4HO_5. **D.** CH_2O. $C = 12$
E. $C_3H_6O_3$. $O = 16$

Items 178 and 179 refer to the following data. The molecule of a certain compound is composed of carbon and hydrogen atoms. The weight of the molecule is 58 times the weight of the hydrogen atom. By an analysis it is shown that about 5/29 of the weight of the molecule is due to hydrogen, the remainder being due to carbon.

178. How many carbon atoms are in the molecule of the compound?
(3.00)

A. 1. **B.** 2. **C.** 3. **D.** 4. **E.** 5.

179. How many hydrogen atoms are in the molecule of the compound?
(3.00)

A. 10. **B.** 8. **C.** 6. **D.** 4. **E.** 5.

Items 180 - 182 refer to the experimental use of a pycnometer (specific gravity bottle). In this case the object was to determine the density of an unknown solid in the form of small shot which could be poured into the bottle. Assume that the density of water is 1 gm./cm.^{3} The following data were collected:

Weight of empty bottle	18.3 gm.
Weight of bottle when filled with water	43.3 gm.
Weight of bottle when partly filled with shot ..	67.2 gm.
Weight of bottle with shot and water to fill the crevices	77.3 gm.

180. The volume of shot used was (in cm.^{3})
(3.00)

A. 25.0. **B.** 14.9. **C.** 48.9. **D.** 10.1
E. none of these.

181. The density of the unknown shot in gm./cm.^{3} was calculated by
(3.00)

A. 49.9/25. **B.** 48.9/10.1. **C.** 48.9/14.9.
D. 67.2/14.9. **E.** none of these.

182. The best explanation of the use of a bottle stopper with a hole through the center is
(3.00)

A. it helps to prevent breakage if hot water is used.
B. it allows for expansion when the temperature changes.
C. it permits complete filling of the bottle.
D. it helps to remind the student to keep the bottle upright while weighing.
E. it admits air to the top of the water surface while weighing.

183. Which of the following pairs of simultaneous observations of the angular altitude of a passing plane will permit the operators to solve their problem using only the simple trignometric functions for right angles?
(3.00)

A. There is insufficient data given to answer this item.
B. Observer A observes 42°32′; Observer B observes 43°00′.
C. Observer A observes 42°30′; Observer B observes 43°30′.
D. Observer A observes 47°16′; Observer B observes 42°45′.
E. Observer A observes 48°00′; Observer B observes 43°00′.

184. At a specified instant Observer A records the angular altitude of a passing plane as 90°00′ and Observer B records an angular altitude of 42°35′. Which of the following expressions will give the accurate altitude of the plane with a minimum amount of calculation?
(3.00)

A. Altitude = .6766 × 25,000 ft.
B. Altitude = .7363 × 25,000 ft.
C. Altitude = .9190 × 25,000 ft.
D. Altitude = .6758 × 25,000 ft.
E. Altitude = .0777 × 25,000 ft.

185. The altitude obtained from observations of the plane in the preceding item is equal to
(3.00)

A. 16,915 ft. **B.** 18,407 ft. **C.** 22,975 ft.
D. 16,890 ft.
E. some value other than one of the above four.

Items 186 - 189. The operators of two control stations along an airway were assigned the problem of determining the altitude of passing aircraft. In addition to being able to observe the angle between the observer's horizon and a passing plane they had the following data:

Distance between the two stations......... 25,000 ft.
In a right triangle the following ratios may be identified:

$$\frac{\text{opposite side}}{\text{hypotenuse}} = \text{sine}$$

$$\frac{\text{adjacent side}}{\text{hypotenuse}} = \text{cosine}$$

$$\frac{\text{adjacent side}}{\text{opposite side}} = \text{tangent}$$

The following values may be assigned to the functions indicated:

angle	sines	cosines	tangents	angle
42°00′	.6691	.7432	.9004	48°00′
10	.6713	.7412	.9057	50
20	.6734	.7392	.9110	40
30	.6756	.7373	.9163	30
40	.6777	.7353	.9217	20
50	.6799	.7333	.9271	10
43°00′	.6820	.7314	.9325	47°00′
angle	cosines	sines	cotangents	angle

186. From the problem described and the type of data available the operators can proceed most effectively by applying the principle
(3.00)

A. the shortest distance between two points is a straight line.
B. two triangles are equal if they have two corresponding sides and their included angle equal.
C. the ratios between the corresponding sides of similar triangles are equal.
D. if two parallel lines are cut by a transversal the alternate interior angles are equal.

187. (3.00) To proceed, without referring to additional data or techniques, the two operators will have to determine the angle between their horizons and a plane when

A. either of two of the following four conditions exist.
B. the plane first comes into view of both observers.
C. the plane is passing directly over one of the observers.
D. the plane is just leaving sight of both observers.
E. a line passing from the plane to one of the observers bears 90° to the line connecting the plane to the other observer.

188. (3.00) At a specified instant the angle between the horizon and a passing plane is recorded by Observer A as 90°00′ and by Observer B as 40°45′. If you were Observer A your next step should be to

A. recheck your observations.
B. diagram the conditions of the observations.
C. consult a table of the values of trignometric functions.
D. consult a table of squares and square roots.

189. (3.00) If the plane in the previous item continued at the same altitude and direction and passed directly over Observer B, at the instant it was directly over B, Observer A would measure the angle between his horizon and the plane as equal to

A. there is insufficient data given to answer this item.
B. 90°00′. **C.** 47°45′. **D.** 42°45′.
E. some value other than the above three.

For items 190 - 193 use this section of a table of trigonometric functions.

	Sin	Cos	
12°00′	.2079	.9781	78°00′
10′	.2108	.9775	77°50′
20′	.2136	.9769	40′
30′	.2164	.9763	30′
40′	.2193	.9757	20′
12°50′	.2221	.9750	10′
13°00′	.2250	.9744	77°00′
10′	.2278	.9737	76°50′
	Cos	Sin	

	Tan	Cot	
12°00′	.2126	4.705	78°00′
10′	.2156	4.638	77°50′
20′	.2186	4.574	40′
30′	.2217	4.511	30′
40′	.2247	4.449	20′
12°50′	.2278	4.390	10′
13°00′	.2309	4.331	77°00′
10′	.2339	4.275	76°50′
	Cot	Tan	

	Sec	Csc	
12°00′	1.022	4.810	78°00′
10′	1.023	4.745	77°50′
20′	1.024	4.682	40′
30′	1.024	4.620	30′
40′	1.025	4.560	20′
12°50′	1.026	4.502	10′
13°00′	1.026	4.445	77°00′
10′	1.027	4.390	76°50′
	Csc	Sec	

190. (2.10) The cosine of 77°12′ equals

A. .2215. **B.** .2187. **C.** .2227. **D.** .2199.
E. none of these.

191. (2.10) The angle with a sine of .2170 is

A. 12°28′. **B.** 12°42′. **C.** 12°38′. **D.** 13°28′.
E. none of these.

Item 192 deleted.

193. (3.00) When a furniture mover pulls a 500 lb. piano with a force of 80 lb. at an angle of 13° with the horizontal, the force effective in moving it across the floor is

A. 18 lb. **B.** 78 lb. **C.** 80 lb. **D.** 112.5 lb.
E. 487.5 lb.

194. (3.00) It is found that 2.00 liters of a gas at standard conditions weigh 4.50 grams. The gram-molecular weight of the gas (in grams) is

A. 4.50. **B.** 2.25. **C.** 50.4. **D.** 25.2.
E. none of these.

195. (3.00) If a stone attached to a string 2 feet long is swung through an angle of 90°, how long is the arc? (Suggestion: 2 π radians = 360°)

A. 3.14 ft. **B.** 1.57 ft. **C.** 2.00 ft. **D.** 12.56 ft.
E. none of these.

196. (3.00) If a force of 100 lbs. makes an angle of 67° with the horizontal, the horizontal component of the force equals approximately

A. 92 lb. **B.** 250 lb. **C.** 236 lb. **D.** 40 lb.
E. 78 lb.

Items 197 - 202 are concerned with two blocks, block A and block B. Block A has a specific gravity of .75 and a weight of 20 grams.

197. (3.00) The density of the block A is

A. .75 g/cc. **B.** .25 lbs/cu′. **C.** .50 g/cc.
D. 25 lbs. **E.** cannot be determined.

198. (3.00) The volume of block A in cubic centimeters is approximately

A. 22 cc. **B.** 27 cc. **C.** 32 cc. **D.** 95 cc.
E. the volume cannot be determined with the information available.

199. (3.00) The block A will displace when floating in water,

A. 10 g. of water. **B.** 20 g. of water.
C. 30 g. of water. **D.** 40 g. of water.
E. the displacement cannot be determined with the information available.

200. (3.00) Block B has the same weight as A but twice the volume. It is placed in the water. It will float with approximately

A. 34 cc above water. **B.** 1.0 cc above water.
C. 75 cc above water. **D.** 20 cc above water.
E. the answer cannot be determined with the information available.

201. (3.00) If block A is floated in water and a volume of oil of specific gravity .5 is poured on the water, the block will (assume the depth of water and the depth of the oil are both greater than the height of the block)

A. float with the same volume submerged in the water as before the oil was poured in.
B. float with less volume submerged in water than before the oil was poured in.
C. float with more volume submerged in the water than before the oil was poured in.
D. rise to the surface of the oil with part of the block in air.
E. sink to the bottom of the vessel. (The total volume of the block now in water.)

202. (3.00) If block A is floated in water in a beaker and oil of specific gravity .9 is poured on the water as in item 201 the block will

A. float higher in the water but not rise out of the water into the oil.
B. float lower in the water but not sink to the bottom of the container.
C. float with the same volume submerged in the water as before the oil was poured in.
D. rise to the surface of the oil with a part of the block projecting into the air.
E. sink to the bottom of the container. (The total volume of the block now in water.)

203. (3.00) If a distant object at ground level is viewed from the top of 1000 ft. tower and the angle of depression is 12°, the horizontal distance from the tower to the object is about

A. 4710 ft. **B.** 2080 ft. **C.** 9800 ft. **D.** 213 ft.
E. none of these.

204. (3.00) Iron reacts with sulfur as in the equation, $Fe + S \rightarrow FeS$. The approximate atomic weight of iron is 56, of sulfur is 32. The number of grams of FeS that can be obtained from 100 gm. of S is approximately

A. 57. **B.** 175. **C.** 275. **D.** 157. **E.** 36.

205. (3.00) Six hundred grams of Substance A at 50°C. was mixed with 600 grams of Substance B at 30°C. in a calorimeter. The equilibrium temperature was 43°C. Disregarding any heat change in the calorimeter, the specific heat of Substance A can be calculated to be

A. equal to that of Substance B.
B. higher than that of Substance B.
C. lower than that of Substance B.
D. a comparison of the specific heats cannot be made from this data.

206. (3.00) Twenty grams of a hypothetical compound X_2Y, were decomposed. The resulting element X weighed 10 grams. If the atomic weight of element Y is 20, what is the atomic weight of X?

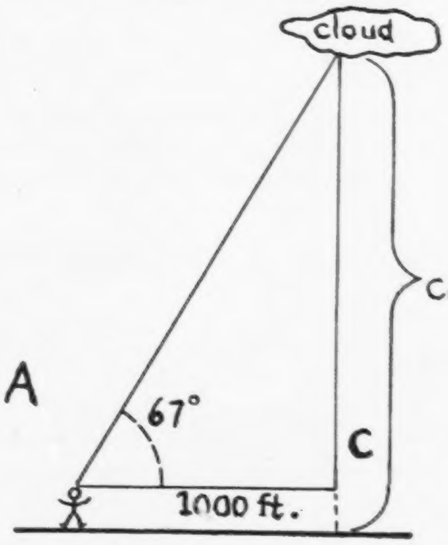
A. 2. **B.** 5. **C.** 10. **D.** 20. **E.** 40.

207. (3.00) How many pounds of Mg metal can be obtained from 100 lbs. of $MgCO_3$? Atomic weights: Mg, 24; C, 12; O, 16. The answer is approximately

A. 16. **B.** 24. **C.** 28. **D.** 48.
E. none of these.

For item 208 refer to this diagram showing how the ceiling is determined at night at an airport using a clinometer to measure the angle of elevation at A. A search light throws a vertical beam upward at C which reveals the cloud.

sin 67° = .9205
cos 67° = .3907
tan 67° = 2.3559
cot 67° = .4245

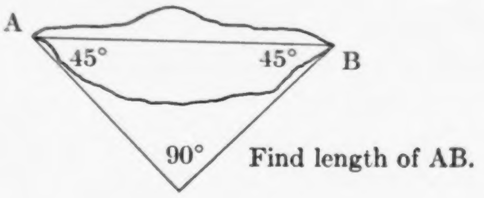


208. (3.00) If the height of the man or clinometer is 6 feet, angle A 67°, and the base line along the airport runway is 1000 feet, the height of the ceiling is

A. 2,355.9 feet. **B.** 426.2 feet. **C.** 2361.9 feet.
D. 9211.0 feet. **E.** 9,205.0 feet.

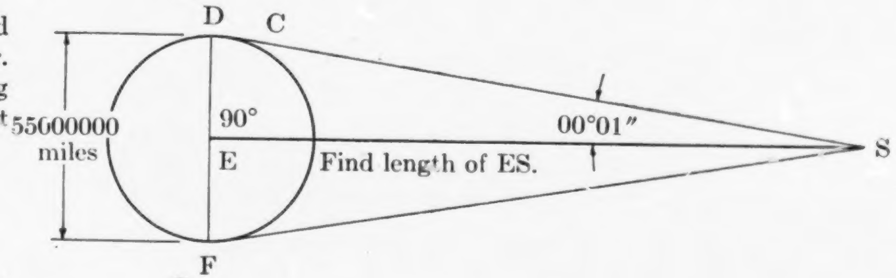
209. (3.00) Which of the following problems could not be solved with the data given and a table of the values of trigonometric functions?

A.



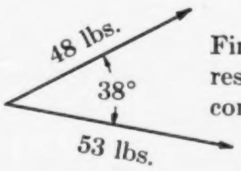
Find length of AB.

B.



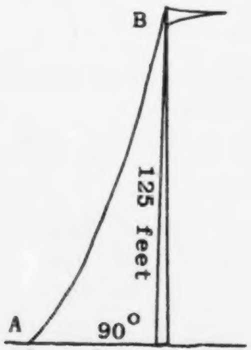
Find length of ES.

C.



Find the value of the resultant of these component forces.

D.



E. All of the above four problems could be solved.

210. (3.00) The atomic weight of Zn = 65, H = 1, Cl = 35.5. When 80 grams of zinc react with sufficient hydrochloric acid to dissolve the metal, the number of grams of hydrogen formed is about

A. 1.5. **B.** 2.5. **C.** 3.5. **D.** 4.5.
E. none of these.

Items 211 and 212. In laboratory work on the Law of Definite proportions, a student burned 1 gram of Mg and produced 1.67 grams of MgO. The average results of the class were the same.

211. (3.00) From this experiment, the atomic weight of Mg must be about

A. 10.7. **B.** 24.0. **C.** 26.7. **D.** 9.6.
E. none of these.

212. (3.00) The ratio of oxygen to magnesium is about

A. 5/3. **B.** 3/5. **C.** 1/3. **D.** 3/2.
E. none of these.

213. (3.00) If sulfur is burned as shown by the equation $S + O_2 \rightarrow SO_2$ the number of lbs. of SO_2 obtained by burning 5 lbs. of S with 5 lbs. of O_2 is (Atomic weight S = 32, O = 16)

A. 5 lbs. **B.** 10 lbs. **C.** 15 lbs. **D.** 64 lbs.
E. none of these.

214. (3.00) The weight of carbon dioxide produced when 1000 gm. of methune burns is

A. 1000 gm. **B.** 2750 gm. **C.** 550 gm.
D. 2000 gm. **E.** 364 gm.

215. (3.00) If a pendulum 3 ft. long swings through an angle of 30°, how long is the arc?

A. .79 ft. **B.** 1.50 ft. **C.** 1.57 ft. **D.** 6.28 ft.
E. none of these.

216. (3.00) The equation for the preparation of calcium chloride is

$$\begin{array}{ccccccccc} CaCO_3 & + & 2HCl & \rightarrow & CaCl_2 & + & H_2O & + & CO_2 \\ 100 & & 73 & & 111 & & 18 & & 44 \end{array}$$

where the number represents the relative weight of each compound. The number of grams of $CaCl_2$ that can be formed from 80 grams of $CaCO_3$ is about

A. 89. **B.** 100. **C.** 111. **D.** 173.
E. none of these.

217. (3.00) The atomic weight of Na = 23, C = 12, O = 16. The formula for sodium carbonate is Na_2CO_3. The percentage of oxygen in the sodium carbonate is about

A. 35. **B.** 40. **C.** 45. **D.** 50. **E.** 55.

Items 218 - 220. The burning of carbon monoxide with oxygen to form carbon dioxide: $2\,CO + O_2 \rightarrow 2\,CO_2$. The atomic weight of carbon is 12, oxygen 16.

218. (3.00) The number of grams of oxygen needed to burn 10 gms. of carbon monoxide is

A. 5.71. **B.** 6.35. **C.** 15.7. **D.** 17.5.
E. none of these.

219. (3.00) The number of liters of oxygen needed to form 100 liters of carbon dioxide from 100 liters of carbon monoxide is

A. 20. **B.** 33⅓. **C.** 100. **D.** 200.
E. none of these.

220. (3.00) The per cent of oxygen in carbon dioxide is

A. 37.5%. **B.** 57.1%. **C.** 72.7%. **D.** 75.0%.
E. none of these.

221. (3.00) The lift of an airplane varies directly as the square of the speed. It is found that a plane has a lift of 4000 pounds at a speed of 100 m.p.h.; find the lift at a speed of 150 m.p.h.

A. 4920 pounds. **B.** 8900 pounds.
C. 9000 pounds. **D.** 6000 pounds.
E. 5000 pounds.

222. (3.00) A man climbs a mountain inclined 30° with the horizontal. His pocket barometer shows that he has increased his elevation 2500 ft. The distance that he has traveled up the slope of the mountain is

A. 1000 ft. **B.** 2000 ft. **C.** 3000 ft.
D. 4000 ft. **E.** 5000 ft

223. (3.00) A tower casts a shadow 200 feet long on level ground when the angle of elevation of the sun is 22°. The height of the tower is

A. 50 ft. **B.** 61 ft. **C.** 71 ft. **D.** 81 ft.
E. 100 ft.

224. (3.00) If 10 lb. of magnesium are burned with 6.6 lb. of oxygen to produce magnesium oxide as shown by the equation: $2\,Mg + O_2 \rightarrow 2\,MgO$ the number of gm. of magnesium oxide obtained is (Atomic weights: Mg, 24.3; O, 16.0)

A. 11.6 lb. **B.** 23.2 lb. **C.** 16.6 lb. **D.** 26.6 lb.
E. none of these.

225. (3.00) The reaction of sodium hydroxide and hydrochloric acid is given by the equation: $NaOH + HCl \rightarrow NaCl + H_2O$. How many grams of NaOH are needed to produce 100 gms. of NaCl? (Atomic weights: Na, 23.0; O, 16.0; H, 1.0; Cl, 35.5)

A. 68.4 gm. **B.** 52.3 gm. **C.** 30.8 gm.
D. 23.4 gm. **E.** none of these.

226. (3.00) Calcium carbonate reacts with hydrochloric acid as represented by the equation: $CaCO_3 + 2\,HCl \rightarrow CaCl_2 + H_2O + CO_2$.

If 20 grams of calcium carbonate are placed with 20 grams of hydrochloric acid, how many grams of hydrochloric acid *will be left over* at the close of the reaction?

(Ca = 40, C = 12, O = 16, H = 1, Cl = 35)

A. 7.6. **B.** 5.4. **C.** .70. **D.** 3.7. **E.** 13.

227. (3.00) The equation for the preparation of carbon dioxide is

$$\begin{array}{ccccccccc} CaCO_3 & + & 2HCl & \rightarrow & CaCl_2 & + & H_2O & + & CO_2 \\ 100 & & 73 & & 111 & & 18 & & 44 \end{array}$$

where the numbers are proportional to the relative weights of the compounds. The number of grams of CO_2 obtained from 25 grams of $CaCO_3$ is

A. 6.25. **B.** 11. **C.** 22. **D.** 44.
E. none of these.

228. (3.00) Given the equation: $$\begin{array}{ccccc} CaO & + & H_2O & \rightarrow & Ca(OH)_2 \\ 56 & & 18 & & 74 \end{array}$$

where the numbers below are gram-molecular weights, the number of grams of CaO needed to produce 100 gms. of $Ca(OH)_2$ is

A. 31.1 gms. **B.** 75.7 gms. **C.** 100.0 gms.
D. 132.1 gms. **E.** none of these.

229. (3.00) $NaCl + H_2SO_4 \rightarrow HCl + NaHSO_4$

How many grams of HCl can be prepared from 40 grams of NaCl? (Atomic weights: Na = 23; Cl = 35.5; H = 1)

A. 24.9. **B.** 5.1. **C.** 16.0. **D.** 4.1. **E.** 28.0.

230. (3.00) Given: $NaCl + H_2SO_4 \rightarrow HCl + NaHSO_4$. The number of grams of HCl which can be obtained from 40 grams of NaCl is

A. 25.0. **B.** 53.4. **C.** 64.1. **D.** 23.9.
E. none of these.

231. (3.00) Given the equation $NaCl + H_2SO_4 \rightarrow HCl + NaHSO_4$, how many grams of HCl can be prepared from 40 grams of NaCl? (H = 1, Na = 23, Cl = 35.5)

A. 15.1 gms. **B.** 15.4 gms. **C.** 24.9 gms.
D. 64.1 gms. **E.** none of these.

Items 232 - 234 refer to the equation for the burning of methane. For each item refer to this equation and table of atomic weights:

$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

Atomic weights
C = 12
O = 16
H = 1

232. (3.00) The amount of oxygen required to burn 1000 cu. ft. of methane is

A. 200 cu. ft. **B.** 250 cu. ft. **C.** 1000 cu. ft.
D. 2000 cu. ft. **E.** 4000 cu. ft.

233. (3.00) The amount of carbon dioxide produced when 100 lb. of methane burns is

A. 100 lb. **B.** 275 lb. **C.** 55.0 lb. **D.** 200 lb.
E. 36.4 lb.

234. (3.00) The per cent of carbon in methane is

A. 25%. **B.** 20%. **C.** 75%. **D.** 133%.
E. 300%.

235. (3.00) Methane burns according to the equation $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$. The atomic weights are: C = 12, O = 16, H = 1. The volume of CO_2 produced in burning 100 liters of methane is

A. 50 liters. **B.** 275 liters. **C.** 33.3 liters.
D. 220 liters. **E.** none of these.

236. (3.00) The number of grams of hydrogen in 60 grams of methane is (refer to the data of the preceding item)

A. 15 gms. **B.** 20 gms. **C.** 5 gms. **D.** 3.75 gms.
E. none of these.

Item 237 refers to the equation for the burning of methane. For this item refer to this equation and the atomic weight listed.

$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

Atomic weight
C = 12
O = 16
H = 1

237. (3.00) The volume of oxygen required to burn 100 liters of methane is

A. 20 liters. **B.** 25 liters. **C.** 100 liters.
D. 200 liters. **E.** 400 liters.

238. (3.00) The union of nitrogen and hydrogen with a suitable catalyst and the addition of heat produces ammonia according to the equation:

$N_2 + 3H_2 \rightarrow 2NH_3 + 24{,}00$ calories

Atomic weight
N = 14
H = 1

When 136 liters of ammonia are produced, the number of liters of nitrogen needed is

A. 90.7 liters. **B.** 112.0 liters. **C.** 204.0 liters.
D. 272.0 liters. **E.** none of these.

239. (3.00) $2C_2H_2 + 5O_2 \rightarrow 4CO_2 + 2H_2O$

The statement below which is correct is

A. 4 cc of C_2H_2 will react with 10 cc of O_2 to produce 4 cc of liquid water.
B. 14 cc of O_2 will react with 30 cc of O_2 to produce 24 cc of CO_2.
C. 9 cc of C_2H_2 will react with 12.5 cc of O_2 to produce 18 cc of CO_2.
D. 12.6 cc of C_2H_2 will react with 31.5 cc of O_2 to produce 25.2 cc of CO_2.
E. 10 cc of C_2H_2 will react with 24 cc of O_2 to produce 20 cc of CO_2.

240. (3.00) The reaction for burning hydrogen at a temperature high enough to give the product water in a gaseous state is given by the equation $2\ H_2 + O_2 \rightarrow 2H_2O$. The number of liters of water vapor formed from 50 liters of hydrogen will be

A. 50. **B.** 100. **C.** 150. **D.** 200.
E. none of these.

241. (3.00) If one unit volume of oxygen and two unit volumes of hydrogen are combined at high temperature, the number of unit volumes of water vapor obtained is

A. one. **B.** two. **C.** three.
D. a small fraction of one unit volume.
E. an indeterminate volume greater than three.

242. (3.00) The reaction for burning carbon monoxide may be shown by the equation $2CO + O_2 \rightarrow 2CO_2$ (C = 12; O = 16). The number of grams of oxygen needed to produce 20 grams of carbon dioxide is most nearly

A. 7.3 grams. **B.** 11.4 grams. **C.** 14.5 grams.
D. 3.6 grams.
E. more data is necessary to answer this item.

243. (3.00) The reaction for burning carbon monoxide may be shown by the equation $2CO + O_2 \rightarrow 2CO_2$. The number of liters of carbon dioxide formed from burning 100 liters of carbon monoxide would be

A. 150. **B.** 50. **C.** 200. **D.** 100.
E. more data is necessary.

244. (3.00) The percent of sulfur in sulfuric acid (H_2SO_4) is within 5% of (H = 1, S = 32, O = 16)

A. 16%. **B.** 26%. **C.** 36%. **D.** 46%. **E.** 56%.

245. (3.00) Each element composing H_2SO_4 makes up a certain percent of the total weight of the compound. The percent below which does not represent the percentage of one of these elements in H_2SO_4 is (atomic weights: S = 32, O = 16)

A. 2. **B.** 43. **C.** 32. **D.** 65.

246. In anhydrous copper sulfate, $CuSO_4$, the percent of
(3.00) sulfur is approximately (approximate atomic weights: $Cu = 64$, $S = 32$, $O = 16$)

A. 28. **B.** 71. **C.** 50. **D.** 20. **E.** 80.

247. The percent of H in CH_4 is
(3.00)

A. 20. **B.** 25. **C.** 75. $C = 12$
D. 300. **E.** 133. $H = 1$

248. The percent of nitrogen in NH_4NO_3 is ($N = 14$,
(3.00) $H = 1$, $O = 16$)

A. $\frac{28}{122} \times 100\%$. **B.** $\frac{14}{80} \times 100\%$.
C. $\frac{14}{66} \times 100\%$. **D.** $\frac{28}{80} \times 100\%$.
E. none of these.

249. The percent of hydrogen in NH_4CH is (Atomic weights:
(3.00) $N = 14$, $H = 1$, $O = 16$)

A. 1/35 of 100%. **B.** 4/35 of 100%.
C. 5/35 of 100%. **D.** 30/35 of 100%.
E. none of the above.

250. The percent of hydrogen in NH_4OH is
(3.00)

A. 11.5%. **B.** 14.3%. **C.** 85.7%. **D.** 26.3%.
E. none of these.

251. The percent of hydrogen in NH_4OH is
(3.00)

A. 11.4. **B.** 11.8. **C.** 14.3. **D.** 0.143.
E. 0.118.

252. The weight of nitrogen in 11.2 liters of ammonia, meas-
(3.00) ured at S.T.P., if the atomic weight of nitrogen is 14, is

A. 28 grams. **B.** 7 grams. **C.** 22.4 grams.
D. 14 grams. **E.** none of these numbers.

253. 200 grams of calcium carbonate ($O = 16$, $C = 12$,
(3.00) $Ca = 40$) on heating will yield

A. 112 grams of calcium oxide and 44.8 liters of CO_2 (at S.T.P.)
B. 100 grams of calcium oxide and 44.8 liters of CO_2 (at S.T.P.)
C. 112 grams of calcium oxide and 22.4 liters of CO_2 (S.T.P.)
D. 56 grams of calcium oxide and 44.8 liters of CO_2 (at S.T.P.)
E. none of these numbers.

254. The percentage of aluminum in bauxite ($Al_2O_32H_2O$),
(3.00) ($Al = 27$, $O = 16$, $H = 1$) is

A. 19.6. **B.** 27.0. **C.** 39.1. **D.** 42.7.
E. none of these numbers.

255. The volume of hydrogen at S.T.P. displaced by 0.27
(3.00) grams of aluminum (atomic weight of 27 and valence 3) is

A. 2.24 liters. **B.** 3.36 liters. **C.** 7.72 liters.
D. 0.336 liters. **E.** none of these numbers.

256. Butane burns in air according to the equation
(3.00)

$2\ C_4H_{10} + 18\ O_2 = 8\ CO_2 + 10\ H_2O$
($C = 12$, $H = 1$).

The volume (at S.T.P.) of oxygen required to burn 58 grams of butane is

A. 44.8 liters. **B.** 179.2 liters. **C.** 89.6 liters.
D. 358.4 liters. **E.** none of these figures.

257. A compound of carbon ($C = 12$), hydrogen ($H = 1$),
(3.00) and oxygen has the percentage composition carbon = 52.18%, hydrogen = 13.04%, oxygen = 34.78%. Its simplest formula is

A. CH_3O. **B.** C_2H_9O. **C.** C_2H_6O. **D.** CH_4O.
E. none of the above formulae.

258. A number of volatile compounds of an element X yield the following data:

	Molecular Wt.	Per cent of X
1st compound	92	50
2nd compound	116	20
3rd compound	146	32
4th compound	275	25

The approximate atomic weight of X is

A. 46. **B.** 70. **C.** 12. **D.** 23. **E.** 32.

259. If the atomic weights of nitrogen and oxygen are 14
(3.00) and 16 respectively, the volume of 4.6 grams of NO_2 at 0°C. and half an atmosphere pressure will be

A. 2.24 liters. **B.** 4.48 liters. **C.** 8.96 liters.
D. 224 ml. **E.** 44.8 liters.

260. The oxide of an element contains 32.00% of oxygen and
(3.00) the element has a specific heat of 0.12. Its exact atomic weight must be

A. 51.00. **B.** 102.00. **C.** 50.00. **D.** 25.50.
E. none of these numbers.

261. In the reversible reaction, $A + B \rightleftarrows C + D$, 2 moles
(3.00) each of A and B are present in a liter at the start and equilibrium is reached when the concentration of C reaches 0.5 mole per liter. The equilibrium constant is

A. 1/2. **B.** 1/4. **C.** 1/9. **D.** 1/3.
E. none of these answers.

262. Copper and sulfur combine to form the compound
(3.00) Cu_2S ($Cu = 63.6$, $S = 32$). If 63.6 grams of copper are heated with 64 grams of sulfur, the product will

A. contain 31.8 grams of excess copper.
B. consist of pure Cu_2S.
C. contain 32 grams of excess sulfur.
D. contain 16 grams of excess sulfur.
E. conform to none of the preceding answers.

263. The atomic weight of iron is 56 and of oxygen is 16.
(3.00) Eighty grams of Fe_2O_3 contains how many grams of the element iron?

A. 80. **B.** 56 **C.** 28. **D.** 62. **E.** 75.

264. The atomic weight of aluminum is 27 and that of
(3.00) fluorine is 19. If you had 1.9 grams of F_2 and 2.7 grams of Al, how much AlF_3 could you make?

A. 8.4 grams. **B.** 4.6 grams. **C.** 1.4 grams.
D. 3.3 grams. **E.** 2.8 grams.

265. The atomic weight of Al is 27 and that of O_2 is 16.
(3.00) If you had 10.8 grams of Al and 2240 cubic centimeters of O_2 gas at 0°C. and 760 mm pressure, how much Al_2O_3 could you make?

A. 20.4 grams. **B.** 3.4 grams. **C.** 6.8 grams.
D. 10.2 grams.
E. not enough information to calculate it.

266. Calculate the approximate percentage by weight of
(3.00) sodium in Na_2CO_3. It is about

A. 22%. **B.** 2%. **C.** 43%. **D.** 11%. **E.** 53%.

267. Magnesium (Mg) combines with chlorine (Cl) to give
(3.00) $MgCl_2$. The atomic weight of Mg is 24 and of Cl is 35. Which of the following is true?

A. 24 grams of Mg + 35 grams of Cl_2 = 94 grams of $MgCl_2$.
B. 48 grams of Mg + 35 grams of Cl_2 = 83 grams of $MgCl_2$.
C. 48 grams of Mg + 70 grams of Cl_2 = 118 grams of $MgCl_2$.
D. 24 grams of Mg + 70 grams of Cl_2 = 59 grams of $MgCl_2$.
E. None of the above is correct.

268. An electric spark is passed through a mixture containing
(3.00) 24 grams of oxygen gas and 4 grams of hydrogen gas. After the explosion, there is in the container

A. 24 grams of water and 1 gram of hydrogen.
B. 27 grams of water and 1 gram of hydrogen.
C. 28 grams of water.
D. 24 grams of water and 4 grams of hydrogen.
E. 4 grams of water and 20 grams of oxygen.

269. The molecule of a certain compound is approximately
(3.00) 72 times as heavy as the hydrogen atom, $\frac{60}{72}$ of the weight of the molecule being due to carbon and the remainder being due to hydrogen. What is the composition of the molecule of the compound?

A. C_6H_6. **B.** C_6H_{14}. **C.** C_5H_{12}. **D.** C_5H_5.
E. C_6H_{12}.

270. When limestone ($CaCO_3$) is heated to a sufficiently
(3.00) high temperature in a kiln, the carbon and part of the oxygen are removed and pass off into the atmosphere as carbon dioxide. The residue left is calcium oxide (CaO) and is known as "unslaked lime." How many pounds of carbon dioxide would be liberated for each 1400 pounds of "unslaked lime" obtained?

A. 1100. **B.** 1800. **C.** 44. **D.** 2200. **E.** 800.

271. If calcium oxide and quartz combine to form slag
(3.00) ($CaSiO_3$), what approximate weight of quartz would be used during the formation of 58 pounds of slag? (Answer in pounds.)

A. 120. **B.** 60. **C.** 30. **D.** 112. **E.** 84.

272. The roasting of copper ore is illustrated by the reaction
(3.00) below.

$$Cu_2S + O_2 \rightarrow Cu_2O + SO_2$$

After balancing the reaction, estimate the approximate weight of oxygen required to convert 160 pounds of the ore to oxide. The answer is about

A. 96. **B.** 320. **C.** 48. **D.** 160. **E.** 32.

Items 273 - 274. Assume that 176 grams of CO_2 and 72 grams of H_2O are consumed in the process of photosynthesis.

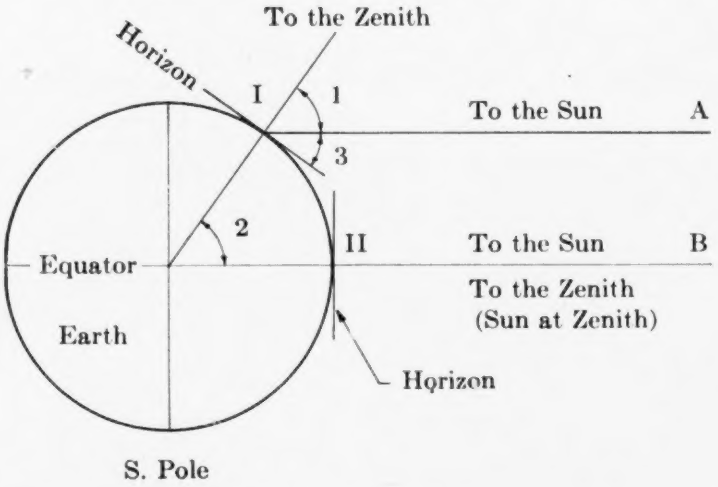
273. How much glucose (in grams) would be formed?
(3.00)

A. 30. **B.** 60. **C.** 120. **D.** 90. **E.** 180.

274. Approximately how much solar energy (in calories)
(3.00) would be absorbed?

A. 1,031,000. **B.** 451,300. **C.** 226,000.
D. 338,500. **E.** 677,000.

Items 275 - 282 are based on the following diagram.



Eratosthenes of Alexandria measured the circumference of the earth in 250 B.C. It is assumed that you are not familiar with his method but that you will become so on a study of the series of items below. These items not only are to be answered by the use of the key but also contain the information necessary for you to understand the procedures used by Eratosthenes. Note, however, that this information can be gained only from *some* of the items, that is, some of the items are statements of actual steps in the solution of the problem; others are true statements but have no bearing on the problem; while others are actually false.

First study all of the items (before attempting to answer any of them) to determine which have a bearing on the problem and what the steps in the solution of the problem are.

Then answer the items by selecting from the key the appropriate statement.

A. Statement *true* and *essential* to the solution of the problem.
B. Statement true but with *no bearing* on the problem.
C. Statement *false.*

All of the statements refer to the above diagram.

275. The sun's rays (lines A and B) are essentially parallel
(4.20) because the sun is at a great distance from the earth compared to the diameter of the earth.

276. Angle 3 equals angle 2 because angle 1 plus angle 3
(4.20) equals 90 degrees.

277. The sun is approximately 186,000,000 miles away.
(4.20)

278. Angle 1 may be measured by measuring the height of
(4.20) the sun above the horizon in degrees and subtracting the height from 90 degrees (90°−angle 3).

279. Angle 1 equals angle 2 because their sides are parallel.
(4.20)

280. (4.20) The sun would have an altitude of 0 degrees if viewed from the north pole at the time of the year represented by the diagram.

281. (4.20) The value of angle 2 in degrees is to the distance in miles from I to II as 360 degrees is to the number of miles around the circumference of the earth.

282. (4.20) Concerning the previous series of items, if angle 3 were 60 degrees and the distance from I to II were 1000 miles, the circumference of the earth would be

A. 12,000 miles. **B.** 4,000 miles. **C.** 20,000 miles
D. 6,000 miles.
E. the necessary information is not given for a solution.

Section III. Appendices

A. Condensed Version of the Taxonomy of Educational Objectives

B. Examples of the Directions or Instructions to Students Used by Various Colleges and Testing Agencies

C. A Selected Bibliography of Published Materials Containing Discussions of Evaluation Problems in Science

SECTION III. APPENDICES

A. CONDENSED VERSION OF THE TAXONOMY OF EDUCATIONAL OBJECTIVES[*]

Cognitive Domain

1.00 Knowledge

Knowledge, as defined here, involves the recall of specifics and universals, the recall of methods and processes, or the recall of a pattern, structure, or setting. For measurement purposes, the recall situation involves little more than bringing to mind the appropriate material. Although some alteration of the material may be required, this is a relatively minor part of the task. The knowledge objectives emphasize most the psychological processes of remembering. The process of relating is also involved in that a knowledge test situation requires the organization and reorganization of a problem such that it will furnish the appropriate signals and cues for the information and knowledge the individual possesses. To use an analogy, if one thinks of the mind as a file, the problem in a knowledge test situation is that of finding in the problem or task the appropriate signals, cues, and clues which will most effectively bring out whatever knowledge is filed or stored.

1.10 **Knowledge of Specifics**

The recall of specific and isolable bits of information. The emphasis is on symbols with concrete referents. This material, which is at a very low level of abstraction, may be thought of as the elements from which more complex and abstract forms of knowledge are built.

1.11 **Knowledge of Terminology**

Knowledge of the referents for specific symbols (verbal and non-verbal). This may include knowledge of the most generally accepted symbol referent, knowledge of the variety of symbols which may be used for a single referent, or knowledge of the referent most appropriate to a given use of a symbol.

[*] To define technical terms by giving their attributes, properties, or relations.

[*] Familiarity with a large number of words in their common range of meanings.

1.12 **Knowledge of Specific Facts**

Knowledge of dates, events, persons, places, etc. This may include either very precise and specific information such as the specific date or exact magnitude of a phenomenon. It may also include approximate or relative information such as an approximate time period or the general order of magnitude of a phenomenon.

[*] The recall of major facts about particular cultures.

[*] The possession of a minimum knowledge about the organisms studied in the laboratory.

1.20 **Knowledge of Ways and Means of Dealing With Specifics**

Knowledge of the ways of organizing, studying, judging, and criticizing. This includes the methods of inquiry, the chronological sequences, and the standards of judgment within a field as well as the patterns of organization through which the areas of the fields themselves are determined and internally organized. This knowledge is at an intermediate level of abstraction between specific knowledge on the one hand and knowledge of universals on the other. It does not so much demand the activity of the student in using the materials as it does a more passive awareness of their nature.

1.21 **Knowledge of Conventions**

Knowledge of characteristic way of treating and presenting ideas and phenomena. For purposes of communication and consistency, workers in a field employ usages, styles, practices, and forms which best suit their purposes and/or which appear to suit best the phenomena with which they deal. It should be recognized that although these forms and conventions are likely to be set up on arbitrary, accidental, or authoritative bases, they are retained because of the general agreement or concurrence of individuals concerned with the subject, phenomena, or problem.

[*] Familiarity with the forms and conventions of the major types of works, e.g., verse, plays, scientific papers, etc.

[*] To make pupils conscious of correct form and usage in speech and writing.

1.22 **Knowledge of Trends and Sequences**

Knowledge of the processes, directions, and movements of phenomena with respect to time.

[*] Understanding of the continuity and development of American culture as exemplified in American life.

[*] Knowledge of the basic trends underlying the development of public assistance programs.

1.23 **Knowledge of Classifications and Categories**

Knowledge of the classes, sets, divisions, and arrangements which are regarded as fundamental for a given subject field, purpose, argument, or problem.

[*] To recognize the area encompassed by various kinds of problems or materials.

[*] Becoming familiar with a range of types of literature.

1.24 **Knowledge of Criteria**

Knowledge of the criteria by which facts, principles, opinions, and conduct are tested or judged.

[*] Familiarity with criteria for judgment appropriate to the type of work and the purpose for which it is read.

[*] Knowledge of criteria for the evaluation of recreational activities.

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[*] *Taxonomy of educational objectives.* A Committee of College and University Examiners, Benjamin S. Bloom, Editor. New York: Longmans, Green and Co., 1954. Pp. 186-192.

[*] Illustrative educational objectives selected from the literature.

1.25 Knowledge of Methodology

Knowledge of the methods of inquiry, techniques, and procedures employed in a particular subject field as well as those employed in investigating particular problems and phenomena. The emphasis here is on the individual's knowledge of the method rather than his ability to use the method.

*Knowledge of scientific method for evaluating health concepts.

*The student shall know the methods of attack relevant to the kinds of problems of concern to the social sciences.

1.30 Knowledge of the Universals and Abstractions in a Field

Knowledge of the major schemes and patterns by which phenomena and ideas are organized. These are the large structures, theories, and generalizations which dominate a subject field or which are quite generally used in studying phenomena or solving problems. These are at the highest levels of abstraction and complexity.

1.31 Knowledge of Principles and Generalizations

Knowledge of particular abstractions which summarize observations of phenomena. These are the abstractions which are of value in explaining, describing, predicting, or in determining the most appropriate and relevant action or direction to be taken.

*Knowledge of the important principles by which our experience with biological phenomena is summarized.

*The recall of major generalizations about particular cultures.

1.32 Knowledge of Theories and Structures

Knowledge of the *body* of principles and generalizations together with their interrelations which present a clear, rounded, and systematic view of a complex phenomenon, problem, or field. These are the most abstract formulations, and they can be used to show the interrelation and organization of a great range of specifics.

*The recall of major theories about particular cultures.

*Knowledge of a relatively complete formulation of the theory of evolution.

Intellectual Abilities and Skills

Abilities and skills refer to organized modes of operation and generalized techniques for dealing with materials and problems. The materials and problems may be of such a nature that little or no specialized and technical information is required. Such information as is required can be assumed to be part of the individual's general fund of knowledge. Other problems may require specialized and technical information at a rather high level such that specific knowledge as well as skill in dealing with the problem and the materials are required. The abilities and skills objectives emphasize the mental processes of organizing and reorganizing material to achieve a particular purpose. The materials may be given or remembered.

2.00 Comprehension

This represents the lowest level of understanding. It refers to a type of understanding or apprehension such that the individual knows what is being communicated and can make use of the material or idea being communicated without necessarily relating it to other material or seeing its fullest implications.

2.10 Translation

Comprehension as evidenced by the care and accuracy with which the communication is paraphrased or rendered from one language or form of communication to another. Translation is judged on the basis of faithfulness and accuracy, that is, on the extent to which the material in the original communication is preserved although the form of the communication has been altered.

*The ability to understand non-literal statements (metaphor, symbolism, irony, exaggeration).

*Skill in translating mathematical verbal material into symbolic statements and vice-versa.

2.20 Interpretation

The explanation or summarization of a communication. Whereas translation involves an objective part-for-part rendering of a communication, interpretation involves a reordering, rearrangement, or a new view of the material.

*The ability to grasp the thought of the work as a whole at any desired level of generality.

*The ability to interpret various types of social data.

2.30 Extrapolation

The extension of trends or tendencies beyond the given data to determine implications, consequences, corollaries, effects, etc., which are in accordance with the conditions described in the original communication.

*The ability to deal with the conclusions of a work in terms of the immediate inference made from the explicit statements.

*Skill in predicting continuation of trends.

3.00 Application

The use of abstractions in particular and concrete situations. The abstractions may be in the form of general ideas, rules of procedures, or generalized methods. The abstractions may also be technical principles, ideas, and theories which must be remembered and applied.

*Application to the phenomena discussed by a paper of the scientific terms or concepts used in other papers.

*The ability to predict the probable effect of a change in a factor on a biological situation previously at equilibrium.

4.00 Analysis

The breakdown of a communication into its constituent elements or parts such that the relative hierarchy of ideas is made clear and/or the relations between the ideas expressed are made explicit. Such analyses are intended to clarify the communication, to indicate how the communication is organized, and the way in which it manages to convey its effects, as well as its basis and arrangement.

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*Illustrative educational objectives selected from the literature.

4.10 **Analysis of Elements**

Identification of the elements included in a communication.

*The ability to recognize unstated assumptions.

*Skill in distinguishing facts from hypotheses.

4.20 **Analysis of Relationships**

The connections and interactions between elements and parts of a communication.

*Ability to check the consistency of hypotheses with given information and assumptions.

*Skill in comprehending the interrelationships among the ideas in a passage.

4.30 **Analysis of Organizational Principles**

The organization, systematic arrangement, and structure which hold the communication together. This includes the "explicit" as well as "implicit" structure. It includes the bases, necessary arrangement, and the mechanics which make the communication a unit.

*The ability to recognize form and pattern in literary or artistic works as a means of understanding their meaning.

*Ability to recognize the general techniques used in persuasive materials, such as advertising, propaganda, etc.

5.00 **Synthesis**

The putting together of elements and parts so as to form a whole. This involves the process of working with pieces, part, elements, etc., and arranging and combining them in such a way as to constitute a pattern or structure not clearly there before.

5.10 **Production of a Unique Communication**

The development of a communication in which the writer or speaker attempts to convey ideas, feelings, and/or experiences to others.

*Skill in writing, using an excellent organization of ideas and statements.

*Ability to tell a personal experience effectively.

5.20 **Production of a Plan, or Proposed Set of Operations**

The development of a plan of work or the proposal of a plan of operations. The plan should satisfy requirements of the task which may be given to the student or which he may develop for himself.

*Ability to propose ways of testing hypotheses.

*Ability to plan a unit of instruction for a particular teaching situation.

5.30 **Derivation of a Set of Abstract Relations**

The development of a set of abstract relations either to classify or explain particular data or phenomena, or the deduction of propositions and relations from a set of basic propositions or symbolic representations.

*Ability to formulate appropriate hypotheses based upon an analysis of factors involved, and to modify such hypotheses in the light of new factors and considerations.

*Ability to make mathematical discoveries and generalizations.

6.00 **Evaluation**

Judgments about the value of material and methods for given purposes. Quantitative and qualitative judgments about the extent to which material and methods satisfy criteria. Use of a standard of appraisal. The criteria may be those determined by the student or those which are given to him.

6.10 **Judgments in Terms of Internal Evidence**

Evaluation of the accuracy of a communication from such evidence as logical accuracy, consistency, and other internal criteria.

*Judging by internal standards, the ability to assess general probability of accuracy in reporting facts from the care given to exactness of statement, documentation, proof, etc.

*The ability to indicate logical fallacies in arguments.

6.20 **Judgments in Terms of External Criteria**

Evaluation of material with reference to selected or remembered criteria.

*The comparison of major theories, generalizations, and facts about particular cultures.

*Judging by external standards, the ability to compare a work with the highest known standards in its field—especially with other works of recognized excellence.

B. EXAMPLES OF THE DIRECTIONS OR INSTRUCTIONS TO STUDENTS USED BY VARIOUS COLLEGES AND TESTING AGENCIES

These sample directions may be helpful in suggesting some of the points to be covered in the general directions which are usually needed at the beginning of a test. The extent and nature of these instructions will depend on local policies and on the extent to which students are already familiar with such examinations. Further instructions may be required for individual items or groups of items.

Sample No. 1 (Dartmouth College)

> DIRECTIONS: Do not write on this book. Use the unprinted area of the answer sheet and the back, if necessary, for your computations.
>
> Select the ONE correct answer to each question and mark the corresponding answer space on the answer sheet. The large numbers represent the question numbers and the small numbers above the parallel lines represent the alternative answers to the question. Select ONLY ONE answer per question. No credit will be given if more than one answer space is marked. To record your choice of the answers make a heavy black mark between the parallel lines. Rub the pencil back and forth a number of times. Make the mark as long as the pair

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*Illustrative educational objectives selected from the literature.

of parallel lines. Erase completely any answer you wish to change.

Be sure to write your name, your section number and the date on the answer sheet.

Sample No. 2 (Michigan State College)

DIRECTIONS:

1. In the lower right hand corner of this booklet *write* your name and student number.
2. On the answer sheet, *print* in the appropriate places your *name* and *student number,* the *date* and *name of the test, term number,* and *instructor's name.*
3. Do any necessary figuring or scribbling on the pages of this test booklet, but do *NOT* mark any answers in it. Answers are to be marked on the answer sheet only.
4. Mark not more than ONE response per item.
5. If you mark more than one response per item, if you leave stray dots on the answer sheet, or if you fail to erase carefully, you may be failed on the examination.
6. Your score on this examination will be the number of answers you have marked correctly.
7. No questions concerning interpretation of the examination will be answered.
8. Please leave as soon as you have finished. Present your answer sheet, test booklet, pencil and identification card to your proctor, or as directed.

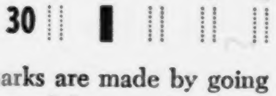
Signature ....
Student No. ....

Sample No. 3 (Chicago City Junior College)

DIRECTIONS: Print your name (last name first), the name of the course, the name of your college and the date on the designated blanks on the answer sheet. (If you are enrolled in Biology III, write Biology III on the blank labeled "Examination.")

Specific directions are stated for each part of the examination, and it is essential that you follow them precisely. If you do not understand the specific directions, ask the proctor for an explanation.

When marking your answers on the answer sheet, you must use a pencil filled with the special scoring machine lead Make your marks thus:



1. Solid black marks are made by going over each mark two or three times and by pressing firmly on your pencil.
2. If you change your mind, erase your first mark completely.
3. Make no unnecessary marks in or around the dotted lines. Do not rest your pencil on a lettered space while deciding which space to mark.
4. Keep your answer sheet on a hard surface while marking your answers.
5. Make your marks as long as the pair of dotted lines.
6. Make *one* mark and *only one* mark after each answer sheet number.

Two hours will be allowed for this examination. When you have finished, turn in the examination booklet and the answer sheet. Be sure to sign the record form.

Sample No. 4 (University of Florida)

GENERAL DIRECTIONS: This examination is to be machine-scored. For the machine to work accurately, the student must use a pencil containing ELECTROGRAPHIC LEAD.

FILL IN THE SPACES AT THE SIDE OF THE ANSWER SHEET WITH THE INDICATED INFORMATION. (Leave blank the spaces headed "A" and "B.")

IMPORTANT: GIVE BUT ONE ANSWER FOR EACH QUESTION; TWO POINTS WILL BE DEDUCTED FOR EACH EXTRA ANSWER. ALSO, AVOID MAKING STRAY DOTS OR MARKS ON YOUR ANSWER SHEET.

When you finish the examination, write the pledge in full on the back of your answer sheet and sign your name to it.

Scoring Formula: R–W/4   *Time Limit:* 180 Minutes

Sample No. 5 (University of Chicago)

Your answers in this examination will be recorded on a special answer sheet instead of on the pages of the test booklet. Your answer sheet will be scored by a machine which will assign to you an accurate score if you carefully observe the following directions:

1. Write your name on the answer sheet in the space provided.
2. Read each question and its lettered answers and decide which answer is correct.
3. Note the *item number* of the question you are answering, and find the *row* on the answer sheet which has the same number.
4. In *this row* find the pair of dotted lines lettered the same as the answer which you consider correct for that question, and *blacken* this answer space, i.e., draw a heavy vertical line between these two dotted lines with the SPECIAL PENCIL provided. MISPLACED ANSWERS ARE COUNTED AS WRONG ANSWERS.
5. Indicate each of your answers with a SOLID BLACK PENCIL MARK drawn vertically between the two dotted lines. Solid black marks are made with the special pencil by going over each mark two or three times and by pressing firmly on your pencil. Do not use any pencil other than the special one furnished you.
6. Make your marks as long as the pair of dotted lines.
7. If you change your answer, erase your first mark *completely.*
8. Make no unnecessary marks in or around the dotted lines; the machine cannot distinguish between intended answers and stray pencil marks.
9. Keep your answer sheet on a hard surface while you are marking your answers.

The electric test-scoring machine is capable of scoring examination papers marked on these special answer sheets by making use of the fact that a solid black pencil mark will carry a current of electricity in the same way that a copper wire does. LIGHT PENCIL MARKS MADE WITH A HARD

PENCIL WILL NOT CARRY A CURRENT OF ELECTRICITY. The machine will not, therefore, give you a correct score unless you indicate your answers with solid black pencil marks.

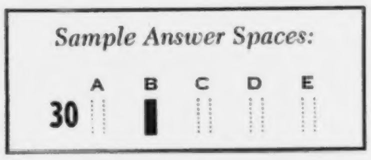
Example

For the following item, *blacken* the answer space which corresponds to the letter of the *one best* completion of the sentence.

Item
Number

30. Chicago is a

(A) state
(B) city
(C) country
(D) town
(E) village


Sample Answer Spaces:

Some of the questions might test ideas with which you are not acquainted. You are advised to read each question and attempt to answer those you understand, as well as those on which you have some idea. But *do not guess wildly.*

Sample No. 6 (State University of Iowa)

PLEASE READ THESE DIRECTIONS CAREFULLY

REMOVE the answer sheet which is loosely inserted in this booklet and fill in the information called for on the top margin. Then finish reading these directions, but do not open the test booklet until the instructor tells you to do so.

INDICATE your choice of the one best answer to each question by making a solid black pencil mark in the proper space on the answer sheet. If you change your mind erase the first mark completely. Do not carelessly or intentionally make any other marks on the answer sheet.

IMPROPER marks will reduce your score on this test.

a. If mismarking (light marks, double marks, stray marks, or improper erasures) causes the test to score differently on two machines, the lower score will be recorded.
b. If mismarking causes the total number of marks registered by the machine to be greater than the total number of questions in the test, the excess will be subtracted from the score.

DO NOT waste time on difficult questions. You may answer questions even when you are not perfectly sure your answers are correct but you should avoid wild guessing.

C. A SELECTED BIBLIOGRAPHY OF PUBLISHED MATERIALS CONTAINING DISCUSSIONS OF EVALUATION PROBLEMS IN SCIENCE

1. Ashford, Theodore A. The college chemistry test in the Armed Forces Institute. *J. Chem. Educ.* 1944, **21** (8), 386-392.

This article reports upon the development of the College Chemistry Test for the Armed Forces Institute. Objectives are stated and illustrated with test items. Other information about the construction and use of tests is given.

2. Bentley, Edward T. Measurement of some aspects of critical thinking. *J. exper. Educ.* 1950, **18**, 263-278.

This study had for its purpose the preparation of instruments to measure pupil ability to think critically with the facts of science. The whole test is included at the end of the article.

3. Bloom, Benjamin, Allison, Jane, and Diederich, Paul. Examining. In *The idea and practice of general education.* Chicago: University of Chicago Press, 1950. Pp. 273-324.

4. Brandwein, Paul F. The College Board's science tests. *Sci. Teacher.* 1952, **19**, 107-113.

This is about a test made up by a College Board based on the principle that the students who are successful in an examination designed primarily to determine their understanding of the strategy and tactics of science will be successful in college science.

Examples of test items used are shown.

5. Burmester, Mary Alice. Behavior involved in the critical aspects of scientific thinking. *Sci. Educ.* 1952, **36**, 259-263.

Keeslar's list of elements of scientific method have been reworded and presented as major objectives involved in the ability to think scientifically.

Eighty types of behaviors which can be measured by objective tests are subsumed under eight abilities: to recognize a problem; to delimit a problem; to distinguish between relevant and irrelevant data; to recognize and accumulate facts related to the solution of a problem; to recognize an hypothesis; to plan experiments to test an hypothesis; to carry out experiments; to interpret data; to apply generalizations to new situations.

6. Burmester, Mary Alice. The construction and validation of a test to measure some of the inductive aspects of scientific thinking. *Sci. Educ.* 1953, **37**, 131-140.

The purpose of this research study was to devise a valid test to measure nine inductive aspects of the ability to think scientifically. Examples are given.

7. Buros, Oscar K. (Ed.). *The fourth mental measurements yearbook.* Highland Park, N. J.: The Gryphon Press, 1953.

8. Dressel, Paul L., and Mayhew, Lewis B. *Science reasoning and understanding.* Dubuque, Iowa: Wm. C. Brown Co., 1954.

This is a handbook developed by a committee of science instructors working with the Cooperative Study of Evaluation in General Education. The handbook discusses the use of current science materials in the classroom and the development of critical thinking or scientific reasoning through such material. The brochure also contains many excellent suggestions and illustrations of questions for testing and broader evaluation.

9. Dressel, Paul L., and Mayhew, Lewis B. *General education: explorations in evaluation.* Washington, D. C.: American Council on Education, 1954.

Chapter 5, "Objectives in Science," discusses the problem of evaluation in science, reports upon the development of several tests and gives numerous illustrations of the type of material used. Chapter 7, "Pervasive Objectives 1: Critical Thinking," should also be of interest to science teachers.

10. Dunning, Gordon M. The construction and validation of a test to measure certain aspects of scientific thinking in the area of first year college physics. *Sci. Educ.* 1949, **33**, 221-235.

The test discussed provided an opportunity for the student to demonstrate the specific behaviors defined in the objectives of the course. Data on the relationship between this test and other factors such as reading ability are reported.

11. Dunning, Gordon M. Evaluation of critical thinking. Atomic Energy Comm., Washington, D. C. *Sci. Educ.* 1954, **38** (3), 191-210.

The purposes of this article are (a) to present the steps by which a classroom teacher of science can construct his own test to measure certain aspects of critical thinking, and (b) suggest as to how scores obtained from these tests may be interpreted.

Illustrations are included.

12. Dyer, Henry S. Can general education courses in the sciences be valuated? In I. B. Cohen and Fletcher G. Watson (Eds.), *General education in science.* Cambridge, Mass.: Harvard University Press, 1952. Pp. 187-204.

The evaluation of a course in General Education should have a twofold purpose: to find out whether the course is accomplishing what it set out to accomplish and to point to the deficiencies that need repair the next time around. More stress should be put on the student's day-to-day behavior inside and out of the classroom.

13. Engelhart, Max D. How teachers can improve their tests. *Educ. psychol. Measmt.* 1944, **4**, 109-124.

Tests should make the students use discriminate thinking. A synthesizing of a pupil's knowledge should be required to answer the novel exercises and questions.

Some examples of the type of question advocated are given.

14. Engelhart, Max D. Evaluation of achievement in chemistry. *J. Chem. Educ.* 1951, **28**, 373-379.

The author makes a number of suggestions with respect to evaluation of the attainment of a variety of objectives and includes some excellent illustrations.

15. Engelhart, Max D., and Lewis, Hugh B. An attempt to measure scientific thinking. *Educ. psychol. Measmt.* 1941, **1**, 289-294.

This paper shows how to write test items which test hypotheses in relation to a given problem. A set of excellent items accompanying the report show how this can be done.

16. Frutchey, Fred P., and Tyler, Ralph W. Examinations in the natural sciences. In Herbert E. Hawkes, E. F. Lindquist and C. R. Mann (Eds.), *The construction and use of achievement examinations.* New York: Houghton Mifflin Co., 1936. Pp. 214-263.

Many different types of test items are exhibited and explained. A discussion of how to distribute these different types of measurement during the course is given.

The technique of building a comprehensive testing program with the cooperation of all teachers concerned is also reviewed.

17. Hall, Thomas S. Implications of general education for the teaching of biology. *J. Gen. Educ.* 1948, **2**, 107-116.

He advocates the written test questions or problems calculated to implicate the student in inferential activities of certain types. We have to draw our own conclusions from speeches, editorials, and general conversation—why not from courses.

A few examples are given.

18. Heil, Louis M. The natural sciences in general education. In Nelson B. Henry (Ed.), *The fifty-first yearbook of the national society for the study of education.* Chicago, Ill.: University of Chicago Press, 1952. Pp. 136-166.

This is a careful examination of the status of science instruction in general education. The statement and role of objectives and the problem of evaluation in reference to this is discussed. Numerous specific illustrations are used.

19. Heil, Louis M., Kambly, Paul E., Mainardi, Marcus, and Weisman, Leah. The measurement of understanding in science. In *The forty-fifth yearbook of the national society for the study of education, Part I.* Chicago, Ill.: University of Chicago Press, 1946. Pp. 104-137.

Devices used for evaluating a student's understanding should correspond to the ideas dealt with directly in day-by-day instruction. The wrong responses of an objective test should be as revealing as the right one.

Examples of the devices for measuring the student's understanding are included throughout the article.

20. Horton, Clark W. *Achievement tests in relation to teaching objectives in general college botany.* The Committee on the Teaching of Botany in American Colleges and Universities of the Botanical Society of America, 1939.

Despite its date this brochure is exceedingly valuable because of many fine examples of test items exemplifying the various objectives in Botany. The discussion of testing problems in reference to the various objectives is also very good.

21. Lindquist, E. F. (Ed.). *Educational measurement.* Washington, D. C.: American Council on Education, 1951.

An outstanding general presentation of the major problems and best practices in measurement and evaluation. Chapters on the various problems are written by those with extensive experience on the particular issues. Chapter 13, "The Essay Type of Examination" by John M. Stalnaker, is particularly recommended for those interested in this mode of testing.

22. McCluskey, K. Lucille. Growth in general education. *N. Cent. Assoc. Qtly.* 1952, **28**, 361-416.

St. Xavier College was introducing a General Education course, including a course in science.

Examples of the type of science questions used to test students at the beginning of the course and again when they were sophomores, to determine if the student retains more over a period of time from the General Education courses than from the traditional courses.

23. Nedelsky, Leo. *Testing for specified objectives of physics teaching.* Chicago: The College and Examiner's Office, University of Chicago, 1952.

This is a manual of examination questions grouped in reference to the objective tested. These materials are excellent.

24. *Science.* Princeton, N. J.: College Entrance Examination Board, 1954.

Although primarily aimed at description of the College Board tests in Biology, Chemistry, and Physics, this brochure contains a good brief discussion of test construction procedures and excellent examples of test items grouped according to the function measured.

25. Smith, Eugene R., and Tyler, Ralph W. *Appraising and recording student progress.* New York: Harper & Bros., 1942.

This volume contains a great deal of information about the development and use of evaluation instruments. Chapter II, "Aspects of Thinking," is particularly relevant to the problems of evaluation in science, even though the discussion is primarily concerned with the high school level.

26. Smith, Victor C. A study of the degree of relationship existing between ability to recall and two measures of ability to reason. *Sci. Educ.* 1946, **30**, 88-90.

Ability to recall information and ability to see relationships between information and related principles are closely correlated. The abilities measured by the mental test and indicated by I.Q. are not necessarily the major abilities involved in learning general science material tested.

Examples of the test items that were used are given.

27. Teichman, Louis. The ability of science students to make conclusions. *Sci. Educ.* 1944, **28**, 268-279.

When the ability to make conclusions, to judge conclusions, and to state reasons why some conclusions are faulty is stressed by the teacher, grades were significantly higher on tests that embodied these three. However, these abilities are not identical.

On test items that did not embody these three there was no appreciable difference between the control students and the non-control group.

28. Teller, James D. Some newer forms of the recognition test. *Sch. Sci. & Math.* 1944, **44**, 859-863.

This article demonstrates with examples how the recall and recognition tests can be used for instructional purposes in science and mathematics.

29. Watson, Fletcher G. What the instructor can do about evaluation: techniques and examples. In I. Bernard Cohen and Fletcher G. Watson (Eds.), *General education in science.* Cambridge, Mass.: Harvard University Press, 1952. Pp. 205-217.

This is a discussion of ways in which the instructor can improve his testing and evaluation techniques. The relative merits of various techniques are considered and several examples are discussed in some detail.

30. Weaver, Edward K. Evaluation of student achievement in science. *Sci. Educ.* 1948, **32**, 81-87.

This article discusses techniques for collecting evidence about a wide range of student development and points to the need for many different approaches to evaluation. Specific examples are exhibited.
17, 213-217.

31. Woodburn, John. Constructing machine scorable examinations in the natural sciences. *Sci. Teacher.* 1950,

It is the author's thesis that if adequate study be given to the statistical performance of trial runs of experimental items it is possible to construct examination items that will reliably measure many levels of performance ordinarily held to be beyond the limits of a short answer or scoring type of examination.

Excellent examples of the type of question he has devised are given throughout the article.

32. Woodburn, John. Visual aids and the problem-solving type of teaching exercise. *Sci. Teacher.* 1953, **20**, 167-169.

Educational films and slides should give more attention to the methodology of science. The origin and testing of hypotheses (genetics, chemical analysis, origin of Crater Lake) may be portrayed by film and color slides prepared from photographed diagrams and charts.

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